The D. H. Hill Library
North Carolina State
College

October 3, 1889

This book was presented
by
W.H.Browne, Jr.
T61
S6
v.8
1900

NORTH CAROLINA STATE UNIVERSITY LIBRARIES

T61
S6
v.8
190

41566

Society for the

DA

This BOOK may be kept out TWO WEEKS ONLY, and is subject to a fine of FIVE CENTS a day thereafter. It is due on the day indicated below:

41566

19Jun'61N

Library Bure

Digitized by the Internet Archive
in 2010 with funding from
NCSU Libraries

http://www.archive.org/details/engineeringeduc08soci

Society

FOR THE

Promotion of Engineering Education.

PROCEEDINGS

OF THE

EIGHTH ANNUAL MEETING,

HELD IN

NEW YORK CITY, JULY 2-3, 1900.

Volume VIII.

EDITED BY

JOHN B. JOHNSON, ALBERT KINGSBURY, HENRY S. JACOBY,

Committee.

NEW YORK:
ENGINEERING NEWS PUBLISHING CO.,
220 BROADWAY.
1900.

Press of
The New Era Printing Company,
Lancaster, Pa.

TABLE OF CONTENTS.—Vol. VIII.

PAGE.
List of Officers, ... v
List of Committees, ... v
List of Council, ... vi
List of Members, ... vii
Geographical Distribution of Members, . . . xxiii
List of Deceased Members, ... xxiv
List of Past Officers, ... xxv
List of Members of Previous Councils, . . . xxvi
Constitution, ... xxvii
Rules Governing the Council, ... xxviii
Proceedings of the Meeting at New York, . . . 1
Communication from the President, ... 1
Report of the Secretary, ... 8
Report of the Treasurer, ... 9
Address by the President: Engineering Education in the United States at the End of the Century.—*Ira O. Baker*, ... 11
Preliminary Report of the Committee on Industrial Education: American Industrial Education: What Shall It Be? 28
Discussion—*Mendenhall, H. G. Prout, M. P. Higgins, D. C. Jackson, R. S. Woodward, Ayres, R. P. Rothwell, Allen, White, Magruder, Kent, Lanza, McNair, E. D. Meier, F. A. Halsey, J. B. Johnson*, ... 59
Secondary Technical Education in Mechanical and Electrical Lines.—*A. L. Williston*, . . . 102
Informal Report of Committee on Entrance Requirements for Engineering Colleges, ... 136
Discussion—*Merriman, McNair, Tyler*, . . . 139
Personality in Teaching.—*J. P. Brooks*, . . . 141
Discussion—*Allen, Gray, Ayres, Thomas, A. W. French, D. C. Jackson, Lanza, J. B. Johnson, Brooks*, . 150
Business Methods in Teaching Engineering.—*A. L. Rice*, 157
Discussion—*Caldwell, Jacoby, J. B. Johnson, R. S. Woodward, Rice, Williston, Allen, Landreth, Snow Gray, F. H. Cilley, Magruder, D. C. Jackson*, .
The Present Status and Tendencies of Engineering Education in the United States.—*R. Fletcher*, . 181

41566

THE PROMOTION OF ENGINEERING EDUCATION.—*W. G. RAYMOND.* 191

DISCUSSION of both of the preceding papers—*Mees, Tyler, R. S. Woodward, Lanza, D. C. Jackson, Alderson, Allen, Ayres, Fletcher, Raymond.* 199

THE RELATIONS OF THE TECHNICAL SCHOOL TO THE MANUFACTURER.—*W. B. SNOW.* 213

DISCUSSION—*D. C. Jackson.* 221

MINOR CONSIDERATIONS AFFECTING THE ARRANGEMENT OF A COURSE OF STUDY IN CIVIL ENGINEERING.—*H. S. JACOBY.* 223

DISCUSSION—*Raymond, J. B. Johnson, Merriman, Hazen, A. W. French, Jacoby, Allen.* 230

ORIGINAL INVESTIGATIONS BY ENGINEERING SCHOOLS A DUTY TO THE PUBLIC AND TO THE PROFESSION.—*A. MARSTON,* 235

DISCUSSION—*Gray.* 244

THE PROJECTION LANTERN IN ENGINEERING EDUCATION.—*C. R. RICHARDS.* 247

DISCUSSION—*Caldwell.* 255

THE DEVELOPMENT AND PRESENT STATUS OF ARCHITECTURAL EDUCATION.—*J. M. WHITE.* 256

DISCUSSION—*Ayres, R. S. Woodward, Alderson, Fletcher, Allen.* 290

THE MANUAL TRAINING HIGH SCHOOL IN GENERAL AND IN ENGINEERING EDUCATION.—*E. A. BENDING.* . . . 295

WHAT SHOULD BE THE CHARACTERISTIC FEATURES OF THE TEACHING OF A COURSE OF MATHEMATICS FOR ENGINEERING STUDENTS?—*A. E. HAYNES.* 308

THE POSSIBILITIES OF CORRESPONDENCE INSTRUCTION.—*G. A. GOODENOUGH.* 315

DISCUSSION—*J. B. Johnson.* 323

THE PRACTICABILITY OF AN INTERCHANGE OF STUDENTS BETWEEN THE LABORATORIES OF DIFFERENT ENGINEERING SCHOOLS.—*W. M. F. GOSS.* 326

THE MODERN MECHANICAL LABORATORY, ESPECIALLY AS IN PROCESS OF EVOLUTION IN AMERICA.—*R. H. THURSTON.* 331

OPERATING WORK AS A FEATURE OF ELECTRICAL LABORATORY TRAINING.—*W. S. ALDRICH.* 359

MEMOIR OF DECEASED MEMBER.

Herbert G. Geer. 371

INDEX. 372

OFFICERS

OF THE

Society for the Promotion of Engineering Education.

1900-1901.

PRESIDENT:

FRANK O. MARVIN, University of Kansas.

VICE-PRESIDENTS:

THOMAS GRAY, Rose Polytechnic Institute.
ALBERT KINGSBURY, Worcester Polytechnic Institute.

SECRETARY:

HENRY S. JACOBY, Cornell University, Ithaca. N. Y.

TREASURER:

CLARENCE A. WALDO, Purdue University, Lafayette, Ind.

STANDING COMMITTEES.

On Entrance Requirements for Engineering Colleges:

HARRY W. TYLER, *Chairman*.
J. J. FLATHER, *Secretary*, J. P. JACKSON, T. C. MENDENHALL, MANSFIELD MERRIMAN, C. D. MARX, F. W. MCNAIR. F. O. MARVIN, J. C. NAGLE, R. B. OWENS, W. D. PENCE.

On Statistics of Engineering Education:

W. T. MAGRUDER, *Chairman*, L. E. REBER, A. N. TALBOT, H. W. TYLER, The President and the Secretary.

COMMITTEE ON INDUSTRIAL EDUCATION:

J. B. JOHNSON, *Chairman*, H. T. EDDY, EDGAR MARBURG, G. F. SWAIN, R. H. THURSTON, C. M. WOODWARD.

COUNCIL.*

Terms of Office Expire in 1901.

Thomas M. Drown, Lehigh University,
Malverd A. Howe, Rose Polytechnic Institute,
Ira N. Hollis, Harvard University,
Gaetano Lanza, Massachusetts Institute of Technology,
Palmer C. Ricketts, Rensselaer Polytechnic Institute,
Robert G. Thomas, South Carolina Military Academy,
Calvin M. Woodward, Washington University.

Terms of Office Expire in 1902.

Brown Ayres, Tulane University,
George W. Bissell, Iowa Agricultural College,
John J. Flather, University of Minnesota,
William T. Magruder, Ohio State University,
Frederick W. McNair, Michigan College of Mines,
J. Madison Porter, Lafayette College,
A. J. Wood, Railroad Gazette.

Terms of Office Expire in 1903.

John P. Brooks, State College of Kentucky,
Dugald C. Jackson, University of Wisconsin,
Edgar Marburg, University of Pennsylvania,
James C. Nagle, Agricultural and Mechanical College of Texas,
N. Clifford Ricker, University of Illinois,
Arthur L. Williston, Pratt Institute.

---

*This list gives only the elective members. The officers (p. i) and the past presidents (p. xxi) are members of the Council *ex officiis*.

LIST OF MEMBERS.

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
ADAMS, COMFORT A., JR. Cambridge, Mass.	Assistant Professor of Electrical Engineering, Harvard University.	1894
ALDERSON, VICTOR C. Chicago, Ill.	Dean of the Technical College, Armour Institute of Technology	1900
ALDRICH, WILLIAM S. Urbana, Ill.	Professor of Electrical Engineering, University of Illinois.	1893
ALLEN, C. FRANK Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
ANDERSON, F. PAUL Lexington, Ky.	Professor of Mechanical Engineering, Kentucky Agricultural and Mechanical College	1894
ANDERSON, DOUGLAS S. University, Lafayette Co., Miss.	Professor of Electrical Engineering, University of Mississippi	1900
ANTHONY, GARDNER C. Tufts College, Mass.	Professor of Technical Drawing, Tufts College	1896
ARNOLD, BION J. Chicago, Ill.	Consulting Electrical Engineer, 1541 Marquette Bldg	1896
AYER, ARTHUR W. Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont	1894
AYRES, BROWN. New Orleans, La.	Professor of Physics and Electrical Engineering, Dean of College of Technology, Tulane University	1898
BAKER, IRA O. Champaign, Ill.	Professor of Civil Engineering, University of Illinois	1893
BALDWIN, WARD Cincinnati, Ohio.	Professor of Civil Engineering, University of Cincinnati	1893
BARBOUR, VOLNEY G. Burlington, Vt.	Professor of Mechanics and Bridge Engineering, Dean of Engineering Department, University of Vermont	1894
BARNEY, SAMUEL E., JR. New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University	1894

Name and Address.	Title.	Date of Membership.
Barraclough, S. Henry..... Sydney, N. S. W., Australia.	Acting Professor of Engineering, Russell School of Engineering, University of Sydney......................	1900
Bending, Edward A.......... Dayton, Ohio.	Principal of Dayton Manual Training School..	1899
Benjamin, Charles H........ Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science.........	1893
Beyer, Samuel W.............. Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State Agricultural College	1899
Beyer, T. Raymond.......... 119 Maplewood Ave., Germantown, Pa.	Civil Engineer..................................	1895
Bissell, George W .... Ames, Iowa.	Professor of Mechanical Engineering, Iowa State Agricultural College........	1894
Bixby, Wm. H................... Cincinnati, Ohio.	Major Corps of Engineers, U. S. Army, U. S. Engineer Office......................	1898
Bohannan, Rosser D.......... Columbus, Ohio.	Professor of Mathematics, Ohio State University......................	1899
Bovey, Henry T .... Montreal, Que.	Professor of Civil Engineering and Applied Mechanics, McGill University....	1893
Bradford, Joseph N.......... Columbus, Ohio.	Associate Professor of Drawing, Ohio State University	1896
Brady, Frank W............... Mesilla Park, New Mex.	Professor of Engineering, College of Agriculture and the Mechanic Arts...	1899
Bray, Charles D............... Tufts College, Mass.	Professor of Civil and Mechanical Engineering, Tufts College..................	1894
Breckenridge, Lester P.... Urbana, Ill.	Professor of Mechanical Engineering, University of Illinois......................	1893
Brooks, John P................. Lexington, Ky.	Professor of Civil Engineering, State College of Kentucky...............	1898
Brooks, Morgan................ Lincoln, Neb.	Professor of Electrical Engineering, University of Nebraska....................	1899
Browne, Wm. H., Jr........... Urbana, Ill.	Assistant Professor of Electrical Engineering, University of Illinois..........	1899
Bruegel, Adolph T............ Brooklyn, N. Y.	Professor of Machine Design, Pratt Institute..................................	1900

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
BULL, STORM Madison, Wis.	Professor of Steam Engineering, University of Wisconsin	1893
BUNTE, HANS Karlsruhe, Germany.	Aulic Counselor, Professor in the Polytechnic, Director of the Institute of Chemistry and Technology and of the Grand-Ducal Experiment Station	1893
BURGESS, CHARLES F. Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin	1896
BURNHAM, ALTON C.		1896
BURNHAM, EDWARD C. Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University	1899
BURR, WILLIAM H. New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
BURRAGE, SEVERANCE Lafayette, Ind.	Instructor in Sanitary Science, Purdue University	1898
BURTON, ALFRED E. Boston, Mass.	Professor of Topographical Engineering, Massachusetts Institute of Technology	1893
CALDWELL, FRANCIS C. Columbus, Ohio.	Associate Professor of Electrical Engineering, Ohio State University	1897
CARPENTER, LOUIS G. Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
CARPENTER, ROLLA C. Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University	1893
CARSON, WILLIAM W. Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee	1894
CHASE, CHARLES H. 37 Lincoln St., Stoneham, Mass.	Instructor in Manual Arts, Tufts College	1900
CHATBURN, GEORGE R. Lincoln, Neb.	Adjunct Professor of Civil Engineering, University of Nebraska	1899
CHAUVENET, REGIS Golden, Colo.	President, State School of Mines of Colorado	1896
CHRISTY, SAMUEL B. Berkeley, Cal.	Professor of Mining and Metallurgy, University of California	1893

Name and Address.	Title.	Date of Membership.
Constant, Frank H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
Cooley, Mortimer E. Ann Arbor, Mich.	Professor of Mechanical Engineering, Unviersity of Michigan	1893
Corthell, Elmer L. 27 Pine St., New York.	Civil Engineer	1895
Cory, Harry T. Cincinnati, Ohio.	Professor of Civil Engineering, University of Cincinnati	1895
Crafts, James M. Boston, Mass.	Professor of Chemistry, Massachusetts Institute of Technology	1898
Crandall, Charles L. Ithaca, N. Y.	Professor of Civil Engineering, Cornell University	1893
Creighton, W. H. P. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
Crenshaw, Bolling H. Auburn, Ala.	Associate Professor of Mathematics and Mechanical Engineering, Alabama Polytechnic Institute	1894
Cross, Charles R. Boston, Mass.	Professor of Physics, Massachusetts Institute of Technology	1895
Cruikshank, Barton Potsdam, N. Y.	President, Clarkson School of Technology	1899
De Bray, M. Paris, France.	Professor, Ecôle des Ponts et Chaussées	1893
Denison, Charles S. Ann Arbor, Mich.	Professor of Descriptive Geometry, Stereotomy and Drawing, University of Michigan	1893
Denton, James E. Hoboken, N. J.	Professor of Mechanical Engineering and Shopwork, Stevens Institute of Technology	1893
Denton, Frederick W. Houghton, Mich.	Superintendent, Winona Mine	1894
Drown, Thomas M. South Bethlehem, Pa.	President, Lehigh University	1895
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
DUDLEY, CHARLES B. Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1894
DURAND, WILLIAM F. Ithaca, N. Y.	Professor of Marine Engineering, Cornell University	1899
EDDY, HENRY T. Minneapolis, Minn.	Professor of Engineering and Mechanics, University of Minnesota	1893
EMORY, FREDERICK L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
ENGLER, EDMUND A. St. Louis, Mo.	Professor of Mathematics, Dean of Engineering School, Washington University	1897
ESTY, WILLIAM Urbana, Ill.	Associate Professor of Electrical Engineering, University of Illinois	1898
FAIG, JOHN T. Lexington, Ky.	Assistant Professor of Mechanical Engineering, Kentucky Agricultural and Mechanical College	1899
FARWELL, ELMER S 30 Broad St., New York.	Steam Engineer, International Paper Co.	1895
FERNALD, ROBERT H. Cleveland, O.	Assistant Professor of Mechanical Engineering, Case School of Applied Science	1899
FISHER, JAMES, JR. Houghton, Mich.	Instructor in Mathematics and Physics, Michigan College of Mines	1899
FLATHER, JOHN J. Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota	1893
FLETCHER, ROBERT Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School, Dartmouth College	1894
FLINT, WALTER Orono, Me.	Professor of Mechanical Engineering, University of Maine	1898
FORTH, FRANCIS C. Manchester, Eng.	Assistant Director, Municipal Technical School	1898
FOSS, FRED. E. State College, Pa.	Professor of Civil Engineering, Pennsylvania State College	1893
FRANKFORTER, GEORGE B. Minneapolis, Minn.	Professor of Chemistry, University of Minn.	1897

Names and Address.	Title.	Date of Membership.
Franklin, William S. Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1900
French, Arthur W. Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute	1900
French, Thomas E. Columbus, O.	Assistant Professor of Drawing, Ohio State University	1899
Fuertes, Estevan A. Ithaca, N. Y.	Director of College of Civil Engineering, Cornell University	1894
Fullan, M. Thomas J. Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute	1897
Fulton, Henry Boulder, Colo.	Professor of Civil Engineering, University of Colorado	1894
Galbraith, John Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science	1893
Giesecke, F. E. College Station, Tex.	Professor of Drawing, Texas Agricultural and Mechanical College	1893
Gill, James H. Minneapolis, Minn.	Instructor in Machine and Tool Construction, University of Minnesota	1896
Goldsborough, Winder E. Lafayette, Ind.	Professor of Electrical Engineering, Director of the Electrical Laboratory, Purdue University	1897
Goodenough, George A. Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois	1900
Goodman, John Leeds, England.	Professor of Engineering, Yorkshire College, Victoria University	1893
Goss, William F. M. Lafayette, Ind.	Professor of Experimental Engineering, Director of Engineering Laboratories, Purdue University	1893
Gray, Thomas Terre Haute, Ind.	Professor of Dynamic Engineering, Rose Polytechnic Institute	1895
Griffin, Charles L. State College, Centre Co., Pa.	Assistant Professor of Machine Design, Pennsylvania State College	1900
Groat, Benjamin F. Minneapolis, Minn.	Instructor in Mechanics, University of Minnesota	1899
Grover, Nathan C. Orono, Me.	Professor of Civil Engineering, University of Maine	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HALL, CHRISTOPHER W. Minneapolis, Minn.	Professor of Geology and Mineralogy, University of Minnesota	1894
HALSTED, GEORGE B. Austin, Tex.	Professor of Mathematics, University of Texas	1899
HAMLIN, GEORGE H. Orono, Me.	Civil Engineer	1895
HAMPSON, WILLIAM B. Lincoln, Neb.	Instructor in Mechanical Engineering, University of Nebraska	1896
HARPER, JOSEPH D. Manhattan, Kan.	Professor of Engineering, Director of Shops, Kansas State Agricultural College	1899
HARRIS, ABRAM W. Orono, Me.	President, University of Maine	1897
HARRIS, ELMO G. Rolla, Mo.	Professor of Engineering, Missouri School of Mines	1894
HATT, WILLIAM K. Lafayette, Ind.	Associate Professor of Applied Mechanics, Purdue University	1895
HAWES, JOSEPH H. Durham, N. H.	Assistant Professor of Drawing, New Hampshire College of Agriculture and the Mechanic Arts	1900
HAYNES, ARTHUR E. Minneapolis, Minn.	Professor of Mathematics, University of Minnesota	1895
HAZEN, JOHN V. Hanover, N. H.	Professor of Civil Engineering, Dartmouth College	1896
HIBBARD, H. WADE Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
HILL, John E Providence, R. I.	Professor of Civil Engineering, Brown University	1894
HITCHCOCK, EMBURY A. Columbus, Ohio.	Associate Professor of Experimental Engineering, Ohio State University	1899
HOAG, WILLIAM R. Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota	1893
HOFMAN, HEINRICH O. Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology	1894
HOLLIS, IRA N. Cambridge, Mass.	Professor of Engineering, Harvard University	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HOOD, OZNI P. Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
HOSKINS, LEANDER M. Stanford University, Cal.	Professor of Applied Mechanics, Leland Stanford Junior University	1893
HOWE, MALVERD A. Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute	1894
HUME, ALFRED University, Miss.	Professor of Mathematics and Acting Professor of Civil Engineering, University of Mississippi	1894
HUMPHREYS, DAVID C. Lexington, Va.	Professor of Civil Engineering, Washington and Lee University	1893
HUTTON, FREDERICK R. New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1894
JACKSON, DUGALD C. Madison, Wis.	Professor of Electrical Engineering, University of Wisconsin	1893
JACKSON, JOHN P. State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College	1894
JACOBUS, D. S. Hoboken, N. J.	Professor of Experimental Mechanics and Engineering Physics, Stevens Institute of Technology	1893
JACOBY, HENRY S. Ithaca, N. Y.	Professor of Bridge Engineering and Graphics, Cornell University	1894
JOHNSON, JOHN B. Madison, Wis.	Dean of College of Mechanics and Engineering, University of Wisconsin.	1893
JOHNSON, LÉWIS J. Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University	1898
JONES, CLEMENT R. Morgantown, W. Va.	Assistant Professor of Mechanical Engineering, West Virginia University.	1895
JONES, FORREST R. Worcester, Mass.	Professor of Machine Design, Worcester Polytechnic Institute	1893
KAY, EDGAR B. Ithaca, N. Y.	Instructor in Civil Engineering, Cornell University	1898
KENT, WILLIAM Passaic, N. J.	Consulting Engineer, Associate Editor of 'Engineering News,' New York City	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
KIDWELL, EDGAR Hancock, Mich .	Superintendent, Arcadian Copper Mining Company	1896
KIMBALL, RODNEY G. Brooklyn, N. Y.	Professor of Applied Mathematics, The Polytechnic Institute of Brooklyn	1894
KINEALY, J. H. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1893
KINGSBURY, ALBERT Worcester, Mass.	Professor of Applied Mechanics, Worcester Polytechnic Institute	1893
KNOCH, JULIUS J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
KYSER, HENRY H. Auburn, Ala.	Instructor in Physics, Director of Physical Laboratory, Alabama Polytechnic Institute	1897
LAMBERT, PRESTON A. South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University	1897
LANDRETH, OLIN H. Schenectady, N. Y.	Professor of Civil Engineering, Union College	1893
LANE, HENRY M. Scranton, Pa.	Principal School of Metal Mining, International Correspondence Schools.	1900
LANPHEAR, BURTON S. Ames, Iowa.	Assistant Professor of Electrical Engineering, Iowa State College	1897
LANZA, GAETANO Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
LA RUE, BENJAMIN F. Scranton, Pa.	Principal School of Civil Engineering, International Correspondence Schools	1899
LAWRENCE, JAMES W. Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College	1898
LORD, NATHANIEL W. Columbus, O.	Professor of Metallurgy and Mineralogy, Ohio State University	1899
LOVE, ANDREW C. College Station, Tex.	Assistant Professor of Drawing, Agricultural and Mechanical College of Texas	1900
LYON, JOSEPH P. Rochester, N. Y.	Assistant Engineer, Erie Railroad Company, No. 102 Chestnut St.	1894

Name and Address.	Title.	Date of Membership.
McClintock, William E. 15 Court Square, Boston, Mass.	Civil Engineer, Instructor in Highway Engineering, Harvard University, Cambridge, Mass.	1898
McColl, Jay R. Knoxville, Tenn.	Professor of Mechanical Engineering, University of Tennessee	1894
McKissick, Anthony F. Auburn, Ala.	Professor of Electrical Engineering, Alabama Polytechnic Institute	1897
McNair, Frederick W. Houghton, Mich.	President, Michigan College of Mines.	1897
Magowan, Charles S. Iowa City, Iowa.	Assistant Professor of Civil Engineering, State University of Iowa	1896
Magruder, William T. Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University	1893
Marburg, Edgar Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania	1894
Marston, Anson Ames, Iowa.	Professor of Civil Engineering, Iowa State Agricultural College	1894
Marvin, Frank O. Lawrence, Kan.	Dean of the School of Engineering, Professor of Civil Engineering, University of Kansas	1893
Marx, Charles D. Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University	1893
Mather, Thomas W. New Haven, Conn.	Principal Boardman Manual Training High School	1894
Mathews, Hubert B. Brookings, S. Dak.	Professor of Physics, South Dakota Agricultural College	1896
Matthews, Charles P. Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University	1898
Maurer, Edward R. Madison, Wis.	Professor of Mechanics, University of Wisconsin	1897
Mees, Carl L. Terre Haute, Ind.	President, Rose Polytechnic Institute	1894
Mendenhall, Thomas C. Worcester, Mass.	President, Worcester Polytechnic Institute	1895
Merriman, Mansfield South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1893

Name and Address.	Title.	Date of Membership.
Miller, Robert S. Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University	1900
Morley, Frederick Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan	1896
Munroe, Henry S. New York, N. Y.	Professor of Mining, Columbia University	1893
Nagle, James C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
Neff, Frank H. Cleveland, Ohio	Professor of Civil Engineering, Case School of Applied Science	1895
Norris, Henry H. Ithaca, N. Y.	Instructor in Electrical Engineering and Electrician to the Department Light, Heat and Power, Cornell University.	1900
Ordway, John M. New Orleans, La.	Professor of Applied Chemistry, Acting Professor of Civil Engineering, Tulane University	1894
Orton, Edward, Jr. Columbus, Ohio.	Professor of Ceramics and Director of the Department of Clay Working and Ceramics, Ohio State University	1900
Ostrander, John E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
Owens, Robert B. Montreal, Que.	Professor of Electrical Engineering, McGill University	1894
Palmer, Walter K. Lawrence, Kansas.	Associate Professor in charge of the Department of Mechanical Engineering, Kansas State University	1899
Patterson, George W., Jr. Ann Arbor, Mich.	Junior Professor of Physics, University of Michigan	1896
Peabody, Cecil H. Boston, Mass.	Professor of Marine Engineering and Naval Architecture, Massachusetts Institute of Technology	1894
Pence, William D. Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Pettee, Charles H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898

Name and Address.	Title.	Date of Membership.
Phillips, James D. Champaign, Ill.	Assistant Professor of Engineering Drawing, University of Illinois	1899
Porter, Dwight Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
Price, Melvin Lincoln, Neb.	Assistant Instructor in Mechanical Drawing and Machine Design, University of Nebraska	1900
Pupin, Michael I. New York, N. Y.	Adjunct Professor of Mechanics, Columbia University	1895
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894
Raymond, William G. Troy, N. Y.	Professor of Geodesy and Road Engineering, Rensselaer Polytechnic Institute	1893
Reber, Louis E. State College, Pa.	Professor of Mechanical Engineering. Pennsylvania State College	1893
Rice, Arthur L. Brooklyn, N. Y.	Professor of Applied Electricity, Pratt Institute	1894
Richards, Charles R. Lincoln, Neb.	Professor of Practical Mechanics, Director of the School of Mechanic Arts, University of Nebraska	1895
Richards, Robert H. Boston. Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
Richter, Arthur W. Madison, Wis.	Assistant Professor of Steam Engineering, University of Wisconsin	1894
Ricker, Nathan C. Urbana, Ill.	Dean of College of Engineering, University of Illinois	1894
Ricketts, Palmer C. Troy, N. Y.	Director, Rensselaer Polytechnic Institute	1893
Riggs, Walter M. Clemson College, S. C.	Instructor in Electrical Engineering, in charge of Electrical Laboratories, Clemson Agricultural College	1897
Ripper, William Sheffield, Eng.	Professor of Engineering, University College	1893

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RITTER, C. WILHELM Zurich, Switzerland.	Professor of Civil Engineering, Federal Swiss Polytechnic	1893
ROBBINS, ARTHUR G. Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
ROBINSON, EDWARD Potsdam, N. Y.	Professor of Mechanical Engineering, Clarkson School of Technology	1899
ROBINSON, FREDERICK H. Newark, Del.	Professor of Civil Engineering, Delaware College	1894
ROBINSON, STILLMAN W. Columbus, Ohio.	Mechanical Engineer and Expert, 1353 Highland St.	1893
ROSEBRUGH, THOMAS R. Toronto, Ontario.	Lecturer in Electrical Engineering, School of Practical Science	1896
SACKETT, ROBERT L. Richmond, Ind.	Professor of Applied Mathematics and Astronomy, Earlham College	1893
SANBORN, FRANK E. Columbus, O.	Director Industrial Arts Department, Ohio State University	1899
SCHMIDT, EDWARD C. Urbana, Ill.	Instructor in Railway Engineering, University of Illinois	1899
SCHUERMAN, WILLIAM H. Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University	1895
SEDGWICK, WILLIAM T. Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology	1896
SHEPARDSON, GEORGE D. Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota	1895
SMART, RICHARD A. Lafayette, Ind.	Associate Professor of Experimental Engineering, Purdue University	1896
SMITH, HAROLD B. Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1898
SMITH, HARRY E. Minneapolis, Minn.	Assistant Professor of Mechanical Engineering, University of Minnesota	1895
SMITH, HERBERT S. S. Princeton, N. J.	Professor of Applied Mechanics, Princeton University	1894
SNOW, CHARLES H. New York, N. Y.	Dean of School of Applied Science, New York University	1895

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SNOW, WALTER B. 29 Russell Ave., Watertown, Mass.	Mechanical Engineer, B. F. Sturtevant Co., Jamaica Plain, Mass.	1899
SOLBERG, HALVOR C. Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College	1894
SPALDING, FREDERICK P. Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri	1893
SPANGLER. H. W. Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania	1893
SPERR, FREDERICK W. Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines	1896
SPINNEY, LOUIS B. Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State Agricultural College	1899
SPRINGER, FRANK W. Minneapolis, Minn.	Instructor in Electrical Engineering, University of Minnesota	1896
STALEY, CADY Cleveland, Ohio.	President. Case School of Applied Science	1894
STANWOOD, JAMES B. Cincinnati, Ohio.	Director, Technical School of Cincinnati	1894
STEVENS, JAMES S. Orono, Me.	Professor of Physics, University of Maine	1898
STEWART, CLINTON B. Anchor, Ill.	Civil Engineer	1894
STEWART, LEWIS B. Toronto, Ontario.	Lecturer in Surveying, School of Practical Science	1897
STOUT, OSCAR VAN P. Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska	1894
STRATTON. SAMUEL W. Chicago, Ill.	Associate Professor of Physics, University of Chicago	1893
STUBBS, JOSEPH E. Reno, Nev.	President, Nevada State University	1897
STURDEVANT, CHAS. R. Lexington, Ky.	Assistant Professor of Electrical Engineering, Kentucky Agricultural and Mechanical College	1899

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
SWAIN, GEORGE F. Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology	1893
TALBOT, ARTHUR N. Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois	1893
TAYLOR, WILLIAM D. Glasgow, Mo.	Chief Engineer, St. Louis, Peoria and Northern Ry. Co.	1894
THOMAS, ROBERT G. Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy	1894
THOMPSON, WILLIAM O. Columbus, O.	President, Ohio State University	1899
THORNBURG, CHARLES L. South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University	1894
THURSTON, ROBERT H. Ithaca, N. Y.	Director of Sibley College, Cornell University	1893
TIMMERMAN, ARTHUR H. St. Louis, Mo.	Assistant Superintendent Wagner Electric Mfg. Co.	1894
TOWLE, WILLIAM M. State College, Pa.	Assistant Professor of Practical Mechanics, Pennsylvania State College	1895
TRAMMEL, ROBERT J. Auburn, Ala.	Instructor in Mechanical Department, Alabama Polytechnic Institute	1896
TURNEAURE, FREDERICK E. Madison, Wis.	Professor of Bridge and Sanitary Engineering, University of Wisconsin	1894
TURNER, DANIEL L. Cambridge, Mass.	Instructor in Surveying and Hydraulics, Lawrence Scientific School, Harvard University	1898
TURNER, WILLIAM P. Lafayette, Ind.	Instructor in Machine Work, Purdue University	1900
TYLER, HARRY W. 419 Boylston St. Boston, Mass.	Professor of Mathematics, and Secretary, Massachusetts Institute of Technology	1894
VAN ORNUM, J. L. St. Louis, Mo.	Professor of Civil Engineering, Washington University	1895
VEDDER, HERMAN K. Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College	1894

DECEASED MEMBERS.

NAME.	YEAR OF ELECTION.	DATE OF DEATH.
CHARLES B. BRUSH	1893	June 3, 1897.
ECKLEY B. COXE	1894	May 13, 1895.
FRANCIS R. FAVA, JR	1894	March 28, 1896.
HERBERT G. GEER	1894	March 7, 1900.
JUSTUS M. SILLIMAN	1894	April 15, 1896.
JAMES H. STANWOOD	1894	May 24, 1896.
ALPHONSE N. VAN DAELL	1897	March 28, 1899.
JOHN R. WAGNER	1894	January 21, 1899.
FRANCIS A. WALKER	1896	January 5, 1897.
DE VOLSON WOOD	1893	June 27, 1897.

PAST OFFICERS.

Special Committee for Division E (Engineering Education), World's Engineering Congress, 1893.

IRA O. BAKER, Chairman,
WM. R. HOAG, Secretary,
MORTIMER E. COOLEY,
HENRY T. EDDY, Vice-Chairman,
C. FRANK ALLEN, Secretary, *pro tem.*
SAMUEL W. STRATTON,
STORM BULL.

PRESIDENTS.

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON, 1897–8,
THOMAS C. MENDENHALL, 1898–9.
IRA O. BAKER, 1899–1900.

VICE-PRESIDENTS.

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON, FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900.

TREASURERS.

STORM BULL, 1893–5,
JOHN J. FLATHER, 1895–9.

SECRETARIES.

JOHN B. JOHNSON, 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900.

---

*Died, June 27, 1897.

Members of Previous Councils.

Terms of Office Expired in 1894.

M. E. Cooley, H. T. Eddy, W. F. M. Goss,
W. R. Hoag, S. W. Robinson, H. W. Spangler,
R. H. Thurston.

Terms of Office Expired in 1895.

H. T. Bovey, W. H. Burr, O. H. Landreth,
Mansfield Merriman, W. G. Raymond, G. F. Swain,
De Volson Wood.*

Terms of Office Expired in 1896.

I. O. Baker, Storm Bull, S. B. Christy,
John Galbraith, J. B. Johnson, F. O. Marvin,
C. D. Marx.

Terms of Office Expired in 1897.

H. T. Eddy, J. J. Flather, J. P. Jackson,
Albert Kingsbury, L. S. Randolph, S. W. Robinson,
R. H. Thurston.

Terms of Office Expired in 1898.

C. F. Allen, C. L. Mees, Mansfield Merriman,
J. M. Ordway, W. G. Raymond, Cady Staley,
R. S. Woodward.

Terms of Office Expired in 1899.

Arthur Beardsley, Robert Fletcher, John Galbraith,
William Kent, T. C. Mendenhall, W. H. Schuerman,
M. E. Wadsworth.

Terms of Office Expired in 1900.

Storm Bull, L. G. Carpenter, Albert Kingsbury,
F. O. Marvin, R. B. Owens, R. L. Sackett,
R. H. Thurston.

---

* Died, June 27, 1897.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education.

---

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. They shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such names, if approved by the Council, shall be voted on by the Society at the annual meeting.

3. OFFICERS.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the past Presidents of the Society shall be members of the Council *ex officiis.*

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. Fees and Dues.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearage shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

6. Meetings.—There shall be a regular meeting occurring at the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

7. Publication.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

8. Amendments.—This Constitution may be amended by a two-thirds vote at any regular meeting, after having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a programme for the same.

Second. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Third. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PROCEEDINGS.

The eighth annual meeting of the Society was held at Columbia University, New York, July 2 and 3, 1900.

MONDAY, JULY 2, 1900.

MORNING SESSION, 10 O'CLOCK.

The meeting was called to order by Vice-President Robert Fletcher.

The Secretary read the following letter from the President of the Society, Professor Ira O. Baker, then absent in Europe.

CHAMPAIGN, ILLINOIS, June 1, 1900.

MEMBERS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION IN ANNUAL MEETING ASSEMBLED.

My Dear Friends:

I regret that I can not be in two places at the same time. If I could, I would be present with you. At the annual meeting a year ago the Nominating Committee mentioned my name in connection with the office of President, and a friend explained that it would not be wise to elect me, as I was intending to spend the present summer in Europe. Apparently the

Library
N. C. State College

supposed objection led the Committee to propose my name. At that time it was expected that the annual meeting would be held in Europe ; but the difficulty of securing ocean transportation led the officers of the Society to arrange for the meeting on this side.

I appreciate the honor of my election and regret that I can not be present to do my part in helping to make the meeting interesting and profitable.

During your meeting I shall be in London attending the annual convention of the American Society of Civil Engineers, and shall often think of you. At the proper time my personal friend and colleague, Professor J. M. White, will read a paper which I have prepared for the occasion.

One of the Vice-Presidents, Dr. Robert Fletcher, has kindly consented to act as President during the annual meeting, and owing to his experience and wisdom he is certain to conduct the meetings with dignity and celerity. Your most efficient Secretary, Professor Edgar Marburg, has been untiring in his efforts to secure an interesting and profitable program, and I heartily congratulate you upon his success in arranging for the meeting.

Wishing you all a pleasant and profitable session, and praying that each of you may have healthful enjoyment and abundant success in your chosen work for the coming year, and hoping that we may all meet at the next annual convention, I am, with highest esteem,

Your obedient servant,

Ira O. Baker.

The reports of the Secretary and the Treasurer were read and accepted. An Auditing Committee, consisting of Professors Allen and Gray, was appointed to examine the Treasurer's accounts and to report at the next session.

The following applicants, favorably reported upon by the Council, were then elected to membership: Edward Orton, Joseph H. Hawes, Robert J. Miller, Charles H. Chase, Henry M. Lane, William P. Turner, Melvin Price, Victor C. Alderson, Charles L. Griffin, Henry H. Norris, James M. White, Andrew C. Love, George A. Goodenough, S. Henry Barraclough, Arthur W. French, Adolph T. Bruegel.

The Chair appointed a Nominating Committee, consisting of the following members: Lanza, R. S. Woodward, Merriman, Hollis, Johnson and Kingsbury.

The Presidential address was then delivered; in the absence of the President, Professor Ira O. Baker, this address was read by Professor J. M. White.

Professor John P. Brooks then read his paper on "Personality in Teaching." In the discussion that followed the speakers were Professors Allen, Gray, Ayres, Thomas, A. W. French, D. C. Jackson, Lanza, J. B. Johnson, and Brooks.

A paper on "Business Methods in Teaching Engineering" was then read by the author, Professor A. L. Rice. The paper was discussed by the following speakers: Professors Jacoby, J. B. Johnson, R. S. Woodward, Williston, Allen, Landreth, Snow, Gray, Cilley, Magruder, and Rice. A written discussion was received from Professor F. C. Caldwell.

AFTERNOON SESSION, 2 O'CLOCK.

The report of the Committee on Industrial Education was read by the Chairman, Professor J. B. Johnson. The discussion of the report was opened by a communication from President T. C. Mendenhall, which was read by the Secretary. By invitation of Professor Johnson the following gentlemen were present at the meeting and took part in the discussion: Mr. F. A. Halsey, New York; Col. E. D. Meier, New York; Col. H. G. Prout, New York; Mr. Richard P. Rothwell, New York; Mr. M. P. Higgins, Worcester. The following members of the Society also participated in the discussion: Professors D. C. Jackson, R. S. Woodward, Ayres, Allen, White, Magruder, Kent, Lanza, McNair, and J. B. Johnson. It was voted that the report be printed in the Proceedings and the committee continued.

The session concluded with the paper on "Secondary Technical Education," which was read by the author, Professor A. L. Williston.

TUESDAY, JULY 3.

MORNING SESSION, 10 O'CLOCK.

Upon recommendation of the Council, the following applicants were elected to membership: Douglas S. Anderson, William S. Franklin.

The Secretary reported that by vote of the Council the officers and Council for the coming year would consider the advisability of holding the next meeting of the Society at Buffalo, in conjunction with meetings of other societies to be held in that city during the Exposition of 1901.

The report of the Nominating Committee was then read; upon motion it was voted to defer action thereon until the afternoon session.

The Chair then appointed the following membership for the Standing Committee on Statistics of Engineering Education, the establishment of such committee having been favorably acted upon by the Council: Magruder, Reber, Talbot and Tyler; the President and the Secretary being members *ex officiis* by vote of the Council.

Professor Robert Fletcher then read his paper on "The Present Status and Tendencies of Engineering Education in America." During the reading of this paper and the following one Professor J. B. Johnson occupied the chair. After the reading of Professor William G. Raymond's paper, "The Promotion of Engineering Education," these two papers were discussed, together with the Presidential address, the custom of the Society with regard to the latter being set aside on this occasion in accordance with the expressed wish of President Baker. The following members took part in the discussion: Professors Mees, Tyler, R. S. Woodward, Lanza, D. C. Jackson, Alderson, Allen, Ayres, Johnson, Fletcher, and Raymond.

The paper on "The Relations of the Technical School and the Manufacturer" was then read by the author, Mr. Walter B. Snow, and was discussed by Professor D. C. Jackson.

Professor H. S. Jacoby's paper, "Minor Considerations Affecting the Arrangement of a Course of Study in Civil Engineering," was read by the author. and discussed by Professors Raymond, Johnson, Merriman, Hazen, French, Allen, and Jacoby.

Then followed Professor Anson Marston's paper, "Original Investigations by Technical Schools: a Duty to the Public and to the Profession," which was read by Professor George W. Bissell. The paper was discussed by Professor Gray.

Professor Charles H. Richards' paper on "The Projection Lantern in Engineering Education" was read by title, in absence of the author.

AFTERNOON SESSION, 2 O'CLOCK.

The first business taken up was the election of officers. The nominees, reported by the Nominating Committee at the morning session, were unanimously elected, as follows:

President, Frank O. Marvin.
Vice-Presidents, Thomas Gray, Albert Kingsbury.
Secretary, Henry S. Jacoby.
Treasurer, Clarence A. Waldo.
Members of the Council:

Dugald C. Jackson.
Edgar Marburg.
John P. Brooks,
James C. Nagle,
Arthur L. Williston,
Nathan C. Ricker.

A vote was then taken on the amendment to Article 5 of the Constitution, which amendment had been duly approved by vote of the entire Council. The

Society voted unanimously to adopt the amendment, making the first sentence of Article 5 read as follows:

"The admission fee which shall cover also the dues for the first year, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting."

Professor Harry W. Tyler, Chairman of the Committee on Entrance Requirements, made an informal report of the progress made by the Committee since the last annual meeting. The report was discussed by Professors Merriman, McNair, and Tyler.

Professor James M. White then read a paper on "The Development and Present Status of Architectural Education." The following members took part in the discussion of the paper: Professors Ayres, R. S. Woodward, Alderson, Tyler, Fletcher, Allen, and White.

The paper on "The Manual Training High School in General and in Engineering Education," by Mr. Edward A. Bending, was read by title, in absence of the author.

Professor Arthur E. Haynes' paper, "What should be the Characteristic Features of a Course of Mathematics for Engineering Students?" and Professor George A. Goodenough's paper, "The Possibilities of Correspondence Instruction" were read by the Secretary; the latter paper was discussed by Professor Johnson.

Professor W. F. M. Goss' paper, "The Practicability of an Interchange of Students between the Laboratories of Different Engineering Schools," was read by title.

The Society passed a vote of thanks to Professor R.

S. Woodward, of Columbia University, in recognition of his many courtesies and tireless efforts in behalf of the members attending the convention.

The meeting then adjourned. The register showed that 45 members were in attendance at the convention.

REPORT OF THE SECRETARY.

Your Secretary begs to submit the following report, which he regrets not to be able to present in person.

At the last annual meeting twenty-nine names were added to the membership list. Since then there has been a loss from all causes of eighteen members, thus leaving a net gain of eleven members for the year. The total membership is now two hundred and forty-nine (249).

The Society suffered a loss by death of one member: Herbert G. Geer, late Consulting Engineer, and sometime Associate in Mechanical Engineering at Johns Hopkins University. He became a member of the Society in 1894; he died on March 7, 1900. A memorial of the deceased will appear in the next volume of the Proceedings.

In pursuance of the favorable vote of the Council, reported at the Columbus meeting, on the proposition for the enlargement of the "Committee on Entrance Requirements for Engineering Colleges," the President has appointed as additional members, Professors McNair, Marvin, Marx, Nagle, Owens, and Pence, all of whom have accepted service.

An affirmative vote of the Council was reached also with reference to the appointment of a Committee for reporting upon "the means by which the Society might best assist in a movement for the promotion of industrial education in the United States," this question having been referred to the Council at the Columbus Meeting. The President has accordingly appointed Professors J. B. Johnson, Eddy, Marburg, Swain, Thurston, and C. M. Woodward.

At the last meeting the Secretary was instructed to take the necessary steps with a view of amending Article 5 of the Constitution relating to fees and dues, so that the first payment of $3 might cover both the admission fee and the dues for the first year. In accordance with the provisions of the Constitution a letter ballot of the Council was taken on this proposed amendment which resulted in an affirmative vote in excess of the prescribed two-thirds. The approval by a two-thirds vote at this meeting will be required to make this amendment operative.

In conclusion, the Secretary would take occasion to congratulate the Society upon its present prosperous state, which points to an era of increased usefulness in the future.

Respectfully submitted,
EDGAR MARBURG, *Secretary.*

TREASURER'S REPORT.

NEW YORK, June 22, 1900.

The Treasurer of this Society would respectfully report as follows:

The total receipts during the year 1899–1900 to date have been $857.08, of which $582 was for current dues, as against $567 last year. Past fees and dues collected last year amounted to $64: this year to $108. A comparison of both pairs of items shows a healthy, favorable growth in membership sentiment. Receipts last year from sale of Proceedings, $220.15: this year from same source, $114.25. The item this year is smaller because a number of technical institutions bought complete sets last year, involving a much smaller expense this year for their continuation.

Up to the present, and representing about ten months' operations, there is, with all bills paid, including an honorarium of $50 to the Secretary, a balance on hand of $390.41, as against $208.68 last year.

Respectfully submitted,
C. A. WALDO,
Treasurer.

Report of Treasurer in detail:

C. A. Waldo, Treasurer, in account with the Society for the Promotion of Engineering Education. Dr. to the following

RECEIPTS.

Cash on hand August 17, 1899	$ 208.68
Sale of Proceedings	114.25
Sale to authors of extras	30.93
Past fees and dues	108.00
Current dues	582.00
Insurance	21.90
	$ 1065.76

Cr. by the following

DISBURSEMENTS.

Stenographer, Columbus	$ 56.20
Printing, Proceedings, extras, etc.	419.63
Postage and stationery	38.36
Secretary's expense	104.19
Rev. stamps and exchange	5.57
Telegraph and express	1.40
Secretary's honorarium	50.00
Cash to balance	390.41
	$ 1065.76

ADDRESS BY THE PRESIDENT.

IRA O. BAKER,
Professor of Civil Engineering, University of Illinois.

ENGINEERING EDUCATION IN THE UNITED STATES AT THE END OF THE CENTURY.

There is no reason apart from custom why any special significance should be attached to the arbitrary measure of time that we call a century. The main course of history is not much affected by the arbitrary transition from one century to another. But custom has established the turn of the century as an appropriate time to record the past and forecast the future. Since to this Society is entrusted more than to any other agency the future of engineering education in this country, and since we as a nation have risen out of the Monroe doctrine and our isolation, and have taken our first steps to become one of the number of great powers that assume to direct the course of civilization and decide the destiny of the rest of the world, and since this nation largely through the work of the engineer is making rapid progress toward the commercial conquest of the world —the present seems an auspicious occasion on which to study briefly the progress of engineering education.

The century just closing has witnessed a marvelous development in all matters relating to education. Probably the most remarkable feature of the educational history of the century is the extension of the opportunities of an education to the common people as a right. To-day there is nothing in this country so free as education, and the United States is far in the lead of foreign countries in school attendance, about one-fourth of the school population of the world being Americans.

At the beginning of the century there were thirty colleges in the United States with about 3,000 students, while to-day there are 472 collegiate institutions with 155,000 students. But the mere increase in numbers is not the most significant feature. The colleges then were of a lower grade than most academies to-day. This is the explanation of the frequent mention in the biographies of men of that time that they graduated at the age of 15 or younger. The remarkable improvements in the methods of instruction have been both a cause and an effect of the popularization of education.

Another important element in the development of education in America has been the munificent contributions of individuals and of governments to the cause of education. The movement in this direction during the closing years of the century, has been at a rapidly accelerated rate, and is therefore an element of great promise for the future.

Technical education, the application of the sciences to the needs of man, is a growth entirely of this century. Apparently the first technical school in the world was the Ecole Polytechnique in France, established in 1794 to train men for the artillery and engineering corps of the army. The U. S. Military Academy was founded in 1802, and for more than thirty years thereafter was the only organized agency for engineering education in America. For three-quarters of a century a surprising proportion of the graduates of this institution practiced engineering in civil life, not because the education there given was what would now be called engineering instruction but because it was the best preparation for engineering practice that could then be obtained. Apparently this fact has been overlooked alike by friendly and unfriendly critics of this noted institution. In 1825 at Troy, N. Y., was organized the first institution in the world for giving instruction in engineering not military. Apparently at the time of the founding of this institution the term civil engineering had not been coined, the word engineering being synonomous with military engineering.

For thirty years after the establishment of the engineering school at Troy, *i. e.*, from 1825 to the close of the civil war, only four engineering schools were founded, of which only two were really entitled to the name engineering. During this time the engineering schools gave but little technical instruction; most of the so-called engineering part of the course consisted of mathematics and elementary science.

In 1862 Congress passed an act giving to the several states public lands for the benefit of "instruction in the arts and sciences relating to agriculture and the mechanical arts." Shortly after the close of the civil war many of our engineering schools were organized under this act. Never was there a movement more timely or more successful than this, since it has resulted in the establishment of sixty-four technical colleges—at least one in each state and territory. Fifty of them give instruction in one or more branches of engineering.

The number of institutions at present giving instruction in engineering is shown in Table I. The institutions are classified with reference to their requirements for admission according to the scheme presented by the Committee on Entrance Requirements—see the annual report of the Society for 1896, pages 103–4. The report of the Committee includes 110 institutions, but the writer concludes from a careful study of their catalogues that at least twelve of these have no engineering course. The writer has received no report from seven of the United States institutions listed by the Committee, nor from the two Canadian engineering schools.

TABLE I.

NUMBER OF INSTITUTIONS GIVING INSTRUCTION IN THE DIFFERENT BRANCHES OF ENGINEERING IN 1898–99.

INSTITUTIONS.		Number Offering Courses in						
Grade.	No.	C. E.	M. E.	E. E.	Min. E.	Arch.	Nav. A.	S. E.
Class A	30	27	21	21	5	8	2	2
Class B	27	24	17	14	10	6		
Class C	20	12	12	7	5	1		
Class D	9	1	9	5				
Class E	3	3	2	2	1			
Total	89	67	61	49	21	15	2	2

Table II. shows the number of students in the several branches of engineering for the year 1898–99 ; and Table III. the number of graduates for the year 1899. These data were collected from the institutions for this purpose. A few schools were not heard from, but in each case they were small ones having few, if any, engineering students, which fact probably accounts, in some cases at least, for their failure to report. Therefore, Tables II. and III. may be considered as representing the total number of engineering students and graduates for the year 1898–99. During the decade 1889–99 the number of students increased from 3,043 to 9,659, or 317 per cent.; and the graduates increased from 483 to 1,413, or 242 per cent. However in this connection averages are misleading, since the rate of growth for the different courses varies greatly. For example, from 1889 to 1899 the increase of civil engi-

TABLE II.

Number of Students in Different Branches of Engineering in 1898–99.

INSTITUTIONS.	Number Offering Courses in							
	C. E.	M. E.	E. E.	Min. E.	Arch.	Nav. A.	S. E.	Total.
Class A	1359	1579	1405	245	366	54	19	5027
Class B	794	435	510	313	20			2072
Class C	463	919	299	298	3			1902
Class D	10	337	156					503
Class E	41	23	27	4				95
Total	2667	3293	2397	860	389	54	19	9679

TABLE III.

Number of Engineering Graduates in 1899.

INSTITUTIONS.	Number of Graduates in							
	C. E.	M. E.	E. E.	Min. E.	Arch.	Nav. A.	S. E.	Total.
Class A	210	299	252	43	54	9	1	868
Class B	143	52	77	14	2			288
Class C	56	89	27	21				193
Class D	5	37	11					53
Class E	5	3	3					11
Total	419	480	370	78	56	9	1	1413

neering graduates was 56 per cent., and of mechanical 117 per cent.: while the entire growth in electrical engineering is practically a matter of the past decade.

Table IV. presents some interesting statistics as to engineering education in comparison with the so-called three learned professions—theology, medicine and law. The data for the first three columns of Table IV. were compiled from Bulletins 7, 8 and 9—"Professional Education in the United States"—published by the University of the State of New York.

TABLE IV.

PROFESSIONAL EDUCATION IN THE UNITED STATES.
DATA FOR 1898–99.

Item.	Theology.	Law.	Medicine.*	Eng'ring.
Schools,	165	86	156	89
Growth since 1878,	32%	144%	82%	21%
Instructors,	1070	970	6416	
Students,	8099	11833	26088	9659
Growth since 1878,	87%	294%	142%	516%
Graduates,	1693	3110	5725	1413
Requirements for Admission:				
College Degree.	43%	2.3% Require College work		
Completion of Junior Year.	2		0.7%	1.1%
" Freshman Year,	11			
4-yr. High School Course,		35%	8%	4.1
3-yr. " " "	11	14	2	24
2-yr. " " "	4	13	3	51
1-yr. " " "	1	9	62	17
Common School "	11	30	19	
None or Indefinite.	17	28	1	4
Total Reported.	100%	100%	100%	100%
Length of Course:				
4-yr. Course,	24%		91%	98%
3-yr. Course,	70	51%	6	1
Less than 3-yr.,	4	43	3	1
Total Reported,	98%	94%	100%	100%
Aver. Length of Yearly Session.	8 mo.	7¼ mo.	7 mo.	8.7 mo.

---

* Does not include Dentistry, Pharmacy, and Veterinary.

The data in Table IV. concerning the length of high-school course required for admission to engineering schools must be regarded as only roughly approximate. It is difficult for one not acquainted with all the facts to determine from the catalogue just what the requirements are; and the need of these data was not foreseen when those in the preceding tables were asked for. Further, the value of a year of high-school study varies greatly even within the limits of a single State, which adds materially to the difficulty of making a correct general statement as to the conditions for admission.

There are several matters in these tables that invite discussion. For example: (1) Why do so few institutions offer instruction in architecture?—see Table I. Why so few students in architecture?—see Table II. (2) The significance of the fact that more than half of the engineering students are receiving their education in Class A institutions, *i. e.*, those having the highest requirements for admission—see Table II. (3) Are the number of graduates more or less than required to fill the ranks of the profession? (4) Is the number of engineering graduates greater or less, in proportion to the demands of the profession, than law and medicine? (5) Do the data in Table IV. justify the usual classification of schools of law and medicine as post-graduate and engineering as under-graduate? In this connection the fact must not be overlooked that some of the students in law and medicine have more or less college training before entering upon their professional course, and the same is true in engineering but to a much less extent. Time forbids a consideration of these questions here.

But statistics can not represent the most important developments in engineering education in the last third of the closing century. Immense strides have been taken in both the methods and the scope of instruction. At the close of the civil war, there were nominally only six institutions giving any grade of instruction in engineering: and for ten or fifteen years thereafter, the engineering instruction offered by the best institutions is hardly deserving the name in comparison with that offered by many institutions at the present time. During this period some of the engineering instruction was practical and not scientific, and some was scientific and not practical; but none of it consisted of the principles of scientific engineering, nor of the relations of the sciences to engineering problems. Text-books were few and poor. The equipment of the schools was inadequate. Then the student went to college to learn details of practice and to fill his note book with formulas; he was reluctant to give his best efforts to the acquisition of fundamental principles and to the development of the ability to see straight and to reason correctly. Happily now all that is changed, and the schools of America are now offering unexcelled facilities for the acquisition of the fundamentals of an engineering education, and the students are laboring heroically to ground themselves in the principles of scientific engineering.

Twenty-five years ago practitioners doubted the value of a technical training for young engineers, and distrusted the engineering graduate, but now general managers and chief engineers prefer technical graduates, since they have been trained in scientific methods of working, and have a knowledge of the fundamental principles underlying all engineering practice, and look out upon the world of truth from the view point of a man of science. The national engineering societies now give credit for training in the engineering school toward the requirements for admission to membership. The most cordial relations now exist between practitioners and the schools of engineering. Within recent years, largely if not mainly through the influence of the technical schools, engineering has ceased to be traditional and has become scientific.

The technical school met with no welcome from the older colleges and universities. In the beginning the devotee of the non-technical subjects was not willing to admit the study of engineering as being upon the same high plane as that of literature, history, and philosophy. Now all who know the facts are ready to admit that the engineering student secures greater advancement during his college career than any other under-graduate. This result is due to the definiteness of the aim of the engineering student, to the stimulus of professional preparation, and to the nature of the study.

One of the most important advances in engineering education has been the introduction of the laboratory method of instruction. Now all of the better institutions have extensive and well-equipped laboratories fitted up especially for experimental work, in which the student receives instruction of the very highest value. In this respect our American schools are unrivaled in the world. In Europe, particularly in Germany, are some notable and well-equipped engineering laboratories which have done much to advance engineering science, but which are used by experts in research and commercial work and not for purposes of instruction. Although our engineering laboratories are maintained primarily for purposes of instruction, a considerable amount of research work is performed in them.

The curriculum of the engineering college at present consists of about 10 per cent. of English or modern foreign language, usually the latter; 30 to 40 per cent. of indirect technical studies, as mathematics, physics, and drawing; and 50 to 60 per cent. of technical work. The tendency is to make the engineering courses as completely professional as are courses in law and medicine. Experience has shown that it is impracticable to teach culture subjects in a course with strongly marked technical tendencies since the student devotes all of his time to the latter and neglects the former. Very recently there has been a tendency to force some of the indirect technical subjects, as advanced algebra and trigonometry, into the preparatory school to get more time in the engineering college for directly technical subjects. The effect of this is to still further curtail the culture studies of the engineering students by eliminating these subjects from the preparatory course.

A number of institutions offer post-graduate instruction in engineering; but the number doing post-graduate work in engineering is less than that in science or literature. In 1898–99 at twenty-three leading institutions the average per cent. of graduate to under-graduate students in non-engineering departments was 9.94; in the engineering departments, 2.3 per cent.; or, in other words, the per cent. doing graduate work in non-engineering courses is more than four times greater than in engineering courses. In the above computations graduates doing under-graduate work are considered as under-graduate students. But few, if any, Americans now attend European engineering schools, for it is generally conceded that the American schools, in equipment, methods and scope of instruction, are superior to any European schools, at least for American engineers. There are at least three reasons for the relatively small number doing graduate work in engineering:

(a) In many cases, if not in a majority, the chief object of post-graduate study is to secure the preparation necessary for teaching the subject. In many branches the whole range of study, both under-graduate and post-graduate, is purely academic and can be obtained in college environments better than anywhere else. But in engineering the prospective teacher must secure a personal acquaintance with the conditions of practice, which can be obtained only by engaging in actual engineering work. In short, the future teacher of engineering prefers to engage in practice after graduation rather than to return to college halls for further study.

(b) Probably many students pursue an engineering course chiefly because it promises an early means of securing a livelihood; and not unnaturally feel that they can ill afford the means required for post-graduate study. Others who are financially able to continue collegiate work beyond graduation are more anxious to have a part in the activities of the outside world than to pursue post-graduate study. At present the demand for engineering graduates is such that both of these classes, at least those that are really deserving, find little or no difficulty in obtaining remunerative positions in practical engineering work. The engineering college is attempting to give a professional training to its graduates, and it is not surprising that they are anxious to apply in practice that which they have been studying in college. A few years ago many engineering students were unable to resist the seductive offers of a position in actual practice, and left college before graduation. Recently the demand has been almost exclusively for graduates. and now a much larger proportion than formerly stay to graduate. When the competition of young engineers for positions becomes greater, as it doubtless will, probably a greater proportion will be willing to engage in post-graduate study. But this element may not become very effective in increasing the number of engineering students seeking advance collegiate work, for some of them may prefer to serve for a time after graduation as apprentices at comparatively low salaries. Already there are evidences of a considerable tendency in this direction.

(c) The third reason for the less number of post-graduate engineering students is by far the most important. Ordinarily post-graduate study is primarily intended for independent research work ; and this is properly so, for after a young person has been under the direction of tutors for fifteen or twenty years, it is time that he should attempt to blaze a road for himself. If this research work is really original, it will inspire the highest ambition of the student, and will secure his utmost efforts. This class of work will always attract. But departments of study differ greatly in the opportunities for original research. The less fully developed branches of study doubtless have many unsolved problems waiting for investigation, and some of these are such that a recent graduate may reasonably be expected to solve them, or at least to collect part of the data required for a subsequent solution. Engineering post-graduate study offers fewer opportunities for this class of work than many other departments of collegiate work, because of the more fully developed state of most branches of engineering knowledge. Again, the nature of the investigations in many departments are such that they thrive better in a college atmosphere than anywhere else. This is not true, in general, of engineering investigations. Finally, and most important of all, original research in most departments of study is carried on only because of the enthusiasm of the investigator or by public or private benevolence; while in engineering the most of the research work is done in connection with practical work at the expense of individuals or corporations or municipalities having a direct financial interest in the result. Many engineers devote a large part of their time to original research work, and nearly all practicing engineers have more or less of such work. The life of an engineering student before and after graduation is much more nearly continuous than that of a student in most other departments. The ambitious engineering student knows that, shortly, if not immediately, after graduation, he can secure actual engineering practice of high educational value, and many choose positions chiefly with reference to the value of the experience to be obtained. The salary, the educational value of practical experience, the possibility of promotion—all draw the engineering student away from post-graduate study. In other words the study of engineering is essentially graduate work, and there will probably never be any considerable number who will pursue engineering studies beyond the present four-year course. But there are sufficient reasons why adequate provisions should be made for the competent and ambitious few who seek truly graduate instruction in engineering.

All of the preceding is intended to show in rough outline the present state of engineering education, and particularly the rapid growth. The present phenomenal rate of progress promises still larger things for the future, and lays upon this Society important responsibilities in directing the future development of engineering education in America. In this connection there are several matters which invite the careful attention of individual members of this Society, and possibly are worthy of official action by the Society itself.

1. Is any general movement for increasing the requirements for admission desirable? The standard has been rising quite rapidly within the past five years, particularly in mathematics, English and foreign languages; but even now comparatively few of the engineering departments of the universities have as high requirements for admission as the literary departments. Is this justifiable?

Library
N. C. State College

2. Is it wise to require advanced algebra and trigonometry for admission to the engineering courses? Is it wise to require prospective students to take these subjects in secondary schools to the exclusion of subjects in science, literature, or history? Will the forcing of these subjects into the curricula of the secondary schools handicap them in discharging their just obligations toward students who are not seeking an engineering education? Which subject can the preparatory school teach the better? Which school will teach the mathematics the better?

3. At some institutions a considerable number of engineering students have had previous collegiate training. Can anything be done to increase their number?

4. Engineering courses have become so highly specialized that frequently students of one course receive no instruction in the fundamental technical subjects of a closely allied branch of engineering. This practice is burdensome upon the school and is probably not of the highest advantage to the student. But the colleges are not likely to retrace their steps, and therefore the highly specialized course is a condition to be reckoned with. Should anything be done to prevent further specialization? Some students correct the defects due to high specialization by remaining a fifth year and pursuing the allied course. Can anything be done to increase the number who do this?

5. The engineering course of to-day is so loaded with required technical and scientific work that the student has little or no time to cultivate those subjects, indefinitely, but not inappropriately, called the hu-

manities. The engineering students, more perhaps than any others, need training in such subjects. Those who follow the other learned professions deal constantly in their technical work with the relationships of their fellow men, while the engineer in his professional work deals mainly with the inanimate world. The engineer has little opportunity to come into intimate relations with men either through the study of history, economics, and sociology, or through personal contact. The engineer usually possesses strong character, sound judgment, thorough knowledge of his business; but frequently because of a lack of that knowledge which other men consider essential in a liberal education, he is ranked as a relatively uncultivated man, and therefore is unable to exercise the influence his training justifies, and fails to secure the reward his abilities merit. Can the instructors in engineering create in the mind of the engineering student such a hungering for a knowledge of the humanities that he will secure it after graduation by private study and personal intercourse?

Such then are the conditions and the problems of engineering education as we step into the twentieth century. The present conditions have been determined largely by the engineering colleges themselves in advance of the demands of the engineering profession and of the general public, and often in opposition to such demands. Chiefly through the influence of the engineering college the engineering profession has developed during the past third of a century into a truly learned profession. There was never a time in the history of the world when the questions of general education were more carefully considered than at the present; and there was never a time when this country was more concerned with the work of the engineer than now. The nation, just awakening to a consciousness of its power and responsibility, is taking its place among the nations of the earth, and is seeking to decide the destiny of the peoples of the earth. We are now sending our manufactured products to all parts of the world. and if we are to have part in the commercial conquest of the earth, it will be because of the ability, the foresight, the wisdom of our own engineers. The only agency seeking to prepare engineers for their work is the engineering college. Their work in moulding and directing the engineering education of the future will be no less important than in the past. They enjoy the respect and confidence of the public, and a still wider field of influence and responsibility lies open before them. May the deliberations of this Society continue to be a source of strength and inspiration to the engineering colleges. May the engineer of the twentieth century have better technical training, broader culture, and nobler aspirations. May the profession of engineering come to occupy a still higher position in the esteem and respect of the public.

AMERICAN INDUSTRIAL EDUCATION: WHAT SHALL IT BE?

PRELIMINARY REPORT OF A COMMITTEE OF THE SOCIETY.

TO THE PRESIDENT AND THE MEMBERS OF THE SOCIETY.

Gentlemen: Your Committee on Industrial Education was appointed to make a report upon the educational means and methods which they are prepared to recommend as best adapted to advance the general cause of industrial education in this country. By industrial education, we here mean that education which specifically fits one for an industrial vocation or profession. This report has no reference to educational methods in general, nor to those special kinds of training leading towards the fine arts and to the learned professions, other than engineering. Our problem is: What, in addition to the work that is now done in our primary and secondary schools, is it wise for us to attempt to do in schools of various sorts for those young people who are looking for employment in our manufacturing industries, or in commercial houses, or with our great transportation companies, or in those new or more or less original adaptations of material means to social ends which are the peculiar problems of the engineering profession?

If the American people can agree substantially on what ought to be done, they can doubtless find the ways and means for doing it. The object of this report is to bring the members of this Society into substantial agreement as to what it is best to do.

Your committee are of the opinion that heretofore we all have relied too much upon the common schools and upon native ability. We have also conceived the generic American boy or girl as conditioned in a single way, and then have provided educational means and methods to fit this particular condition. But the average or generic boy is no particular boy, and his average condition fits few particular cases. We forget that they are particular boys who are to be trained to do the business of the coming generation, and these particular boys are of all ages, conditions, tastes, and capabilities. Your committee are quite agreed that in America every boy should find his career entirely open at the top. Society here is not to be stratified horizontally, but rather vertically. Our educational ways and means, therefore, must be planned for the purpose of helping every boy or man to make the most of himself, and hence to return to society the most he is capable of. But educational benefits cannot be conferred upon unwilling subjects; neither does the wish always bring the opportunity. Our industrial educational advantages and opportunities, therefore, should be both attractive and available to all classes and to all ages. Any person wishing to improve himself, and to make of himself a more useful citizen should find an opportunity for gratifying this high ambition. There are now in this country only the beginnings of systematic educational opportunities for young people to learn the theory and practice of particular employments for which they are fitted by nature and in which they long to become engaged. We have an excellent system of public and endowed schools in which are more or less well taught the elements of knowledge and in which a very considerable mental capacity is developed. After leaving these schools our boys *know* something, so far as knowledge can be gained from books and oral instruction, but they can *do* little or nothing. This mental, abstract, and memoriter education needs to be supplemented by a manual, industrial, industrial art, commercial, or engineering education if the boy is to become a doer, or a director. He then not only *knows* something but he can *do* something, and because he can do something he is worth something to society. However much a man *knows*, he is a drone in the hive if he cannot do something for the common good. It must be understood we are not asking for utilitarian education *in place of* a mind-informing and mind-developing education, but to supplement such cultural education as the boy or girl has been able to obtain. Neither do we care to insist upon young people availing themselves of this utilitarian education. We are only concerned that it should be offered, and we have every reason to believe that it will be a long time before the facilities will outrun the pressing demand for any kind of education which will enable a man to rise, in honor and in usefulness, in his chosen calling. We are not concerned to find the pupils, we are only concerned to provide the schools.

We are now to try to agree upon the various and sundry classes of theoretical and practical schools which are needed in every populous center in this country in order to meet all the educational demands now existing, to say nothing of the great increase in such demands as soon as we begin to meet them. While your committee may not quite agree in regard to the relative importance of the several classes of schools hereinafter discussed, they are in substantial accord in affirming that all have their place in any thorough and general scheme of technical education for American youth. These classes of schools will now be described and discussed separately.

I. THE MANUAL TRAINING SCHOOL.

There has probably never been a movement in American educational methods which has effected such great changes in so short a time as this manual training school movement. Growing out of the Russian educational exhibit at Philadelphia in 1876, and out of regular class shop-instruction at the Massachusetts Institute of Technology, and still earlier class instruction in shops at the University of Illinois, at the Stevens Institute of Technology, and in the Engineering School of Washington University, St. Louis, the movement was given its American name, form, and significance as a means of general secondary education in the establishment of the St. Louis Manual Training School in 1880. To Dr. C. M. Woodward, a member of this committee, is due the credit of both the name and the school as we know it in this country.*

* It hardly need be said that Dr. Woodward is not responsible for the insertion of the above claim in this report. One member of the committee, also, objects to the mention of any name in this connection. The precedents as to shop-work instruction as here stated are more extended than they were in the report as read at the New York meeting. Hence much of the discussion which followed, on this point, does not exactly fit the text as given above. Dr. Woodward suggests, by letter, that it will be well, in the final

He also was its chief, and at times it seemed, almost its only advocate and defender. He, more than any other, has fixed it in America as a part of the general secondary educational training of a large proportion of our boys who are not drawn especially towards the so-called classical courses of instruction. These schools need not be here described in detail. Suffice it to say they are intended for boys from fourteen to eighteen years of age, and they offer three or four years' courses. The time is divided about equally between manual exercises, drawing, and laboratory work on the one hand and regular academic class-room work on the other. No pretense is made of fitting for particular employments, and in point of fact but a very small percentage of their graduates become and remain artisans. A very large proportion of them go into higher education, a majority of these very naturally taking the engineering courses.

The arguments in favor of these schools are *first*, that they at present draw their students very largely from those who otherwise would leave school altogether at about the age of fourteen or earlier; and *second*, that for a very large proportion of city boys this is at present he best kind of a school they can attend at this age, no matter what they expect to do subsequently. For boys who expect to follow any industrial or commercial vocation, and who have grown up

report of the committee next year, to give a historical statement of the origin of the "Manual Training School" as an institution quite distinct from published theories of "How the use of Tools should be Taught." When and how shop-work was incorporated into the curriculum of engineering students of college grade, is one thing; when and how a "Manual Training School" of secondary grade was actually organized and successfully conducted is quite another thing. J. B. J.

with little manual culture, as is the case with most city boys, the manual training school offers real and permanent advantages. Here the whole boy is sent to school and not merely his head, as Dr. Woodward has so tersely expressed it.

While these schools cannot be called industrial, since they fit for nothing in particular, they belong to the industrial class because the graduates from these schools are well fitted to go at once into any practical trade or business and learn it quickly and effectively. The boys from these schools are not too old or too lofty to enter the industries in the most humble positions; in this particular they have some advantages over the graduates from our high-grade engineering schools. While many of them may begin as artisans, they soon come to be foremen, draughtsmen, salesmen, superintendents, and the like, so that a census taken at any time will show very few of them in the artisan class. This fact which is greatly to the credit of such schools, is frequently cited by shallow critics in disparagement of them; on the other hand it has also gained for them the logical support of the artisan class, who at first were inclined to oppose them. Your committee are in substantial accord, therefore, in their belief in, and in their support of, the manual training schools as now organized and operated. They would like to see these multiply until every boy can have the opportunity of obtaining this kind of education free of charge. The work should be adapted to girls as well as to boys. Thus for girls, cooking, domestic economy, sewing, dress-making, etc., are introduced to offset the shop work of the boys. Whenever manual training is made a fixed part of the public school system, however, they most earnestly recommend to all public school boards a further development of the system, as described under the title of

II. MANUAL TRAINING AND ART EDUCATION AS A PART OF ALL PUBLIC SCHOOL EDUCATION, FROM THE KINDERGARTEN THROUGH THE HIGH SCHOOL.

This we conceive to be the ideal method of introducing both manual and art training into the public schools. In two or three of the lower grades sloyd work and simple hand-tool work might be employed alike for both boys and girls. Free-hand drawing also should be taught alike to all, and this should develop into graduated exercises of simple art-designing, modeling, carving, water-color painting, carpet, wall-paper, and furniture patterns, etc. Elementary needle-work, cooking, and the methods of good plain housekeeping, can be taught successfully to girls of the seventh and eighth grades. If suitable manual work be distributed over the entire public school period it would occupy but a very small part of the average daily program, and all such work would come as a rest and a recreation from the intellectual tasks assigned, so that instead of being a hindrance it would, in fact, be a stimulus and a substantial help in the regular class work. The bringing of these exercises into the regular school course would serve also to hold vast numbers in the schools who now lose interest and drop out for all sorts of frivolous reasons which may be summed up in the two words, "lost interest." Some of our public schools are already moving in this direction. Perhaps the school which has realized this idea as completely as any is the central school at Menomonie, Wisconsin. Here the management has had the wise counsel and the financial aid of a generous citizen, the Hon. J. H. Stout. He erected and equipped most liberally the necessary buildings, and has continued to pay the annual deficits in the expense accounts, but the city will doubtless soon be able to bear the entire expense, as the school has the loyal and enthusiastic support of the entire population. Both the appliances and the instruction in this school are of the highest order and the results are well calculated to astonish anyone who has never seen this system of public instruction in successful operation from the kindergarten through the high school.

This we conceive to be the ideal public school for America. It is expensive for three reasons: The buildings and equipments cost large sums; the instruction is of a high order and must be well paid for; and more than both these, the attendance will be greatly increased in the last six of the twelve years of the course, thus requiring additional buildings, plant, and teaching force for these grades. To fully carry out these ideas, therefore, will greatly increase the running expense of the schools as well as the building and equipment account. And yet your committee believe that this is the goal which we should strive to reach. We must learn first to spend wisely the money now raised in our cities for public school purposes, and then we must almost double the amount.

America is far behind Europe, and particularly France, in all matters pertaining to either fine or industrial art. The highest industrial rewards come for new labor-saving devices and for new art-industrial designs. In the former we already lead the world, but in the latter we are far behind. Art can only thrive under conditions of general comprehension and appreciation. We need an art atmosphere. This requires time in which to educate the whole people along these lines, and to effect this the work must be done in the public schools. Even such artists as we have find a scant support because the masses of the people cannot distinguish between good and poor art, and furthermore they care little for art either good or bad. We are coming to be the richest nation in the world and can well afford to enjoy the highest fruits of wealth, one of which is beautiful and æsthetic surroundings.

But this æsthetic argument will have less weight with our people at this time than will the economic argument which goes with it. The world is now so far advanced in its appreciation of the beautiful that good art pays wherever it is coupled with the useful. Artistic design doubles the value of the product while it may not appreciably add to its cost of production. Almost all our artistic industrial designers now come from Europe. France fixes the fashions of the world because she is the acknowledged authority in art, and her supremacy in art is the very essence of all her material prosperity. But America is rapidly adjusting herself to this demand for more artistic productions, and the time is ripe for the introduction of this art-industrial education in both our public and in our privately endowed schools.

III. THE STATE AGRICULTURAL AND MECHANICAL COLLEGES.

These schools are now found in one form or another in nearly every State in the Union. Established originally under the several land-grant bills, most of them are now liberally supported by direct state aid, and they serve a very large constituency in the fields of agriculture, the mechanic arts and engineering.

While the original purpose of the national appropriations was doubtless to train young men for actual practice in scientific farming and in other industrial pursuits, the students from these schools hitherto have very largely developed into civil, mechanical and electrical engineers. Comparatively few of them have returned to the farms, but many of them are found in the management of our manufacturing industries. These schools all give regular four-year college courses in agriculture and the mechanic arts, but some of them have established short courses in agriculture. In Minnesota and in some other states, to the "agricultural college" has been added an "agricultural school." This is a true secondary industrial school in which the art and science of farming are taught to both boys and girls. It teaches suitable English studies, physics, chemistry, the raising of crops, the use of fertilizers, animal husbandry, butter and cheese-making; cooking, sewing and household economy to the girls, etc. This course is wonderfully successful. Most of these schools, however, have not entirely fulfilled the hopes of their founders in supplying the much needed school training to farmers and artisans which was the primary and original purpose of these enactments. Many of them do form a most important class of engineering schools, since they accept students from the leading high schools of their respective states, and give them a sufficient scientific and practical training to make most useful members of the engineering profession in those grades which make up the great body of practicing engineers. They are near to the people, are comparatively inexpensive, and are very largely attended. These schools have thus more than justified their cost, though many of them are not altogether fulfilling the purposes contemplated in the original enactments.

IV. THE HIGHER ENGINEERING COLLEGES.

These are strictly professional schools of a high grade, which teach both pure and applied science, and which rank with the best of their class in any country. Many of them are privately endowed and others are under the fostering care of the State, either as departments of the State universities or otherwise. In the training of professional engineers they are about all that could be desired; and they are now, and have been for many years, graduating young men who are as well equipped in both theory and practice as can be found perhaps anywhere in the world. These are to be the future leaders in the new adaptations of the laws, the forces, and the materials of nature to the service of man. These are the men who, after some years of practice, can safely be entrusted to solve new problems both successfully and economically. They are the safe counselors and guides of the capitalist in all new mechanical ventures; and they should be in constant demand by public officials, by boards of direction, and by individuals in all cases where large expenditures are to be made, or where important definite results are imperatively required. The scope and purpose of these schools are, however, well understood by our people and they need not be further elaborated here.

V. Monotechnic or Trade Schools.

These schools are comparatively new to the American people. They have long been in operation abroad, and are most fully developed in Germany. But the foreign pattern is not well suited to American needs. There a boy's career can be marked out for him in advance. If he is to be an artisan he is expected always to remain an artisan. The particular trade which he is expected to learn, also, is fixed for him. It is commonly that of his father before him, or that of the prevailing industry of the locality. He is at best a sort of machine, an automaton, worked for what he is worth to the family or to the community and the State. His own individual development is not in question. Most commonly he is not even consulted in the matter. His future is his fate, and he yields to it as gracefully as he can. He has little opportunity to rise above the station in which he finds himself. His career is closed in at the top. Society is stratified horizontally. He finds such solace and comfort as he can by ministering to his bodily comforts and his domestic joys, and frets not over vain ambitions. In fact, ambition is a word of little meaning to him since it can have for him no satisfactory fruition. In these foreign countries, therefore, the trade school is primarily a means of more efficient and more economic production and only incidentally is it a means of personal development. Your Committee believe that this result of trade school instruction abroad is very largely due to the character of the people themselves and should not be charged against the schools.

In America all schooling should lead primarily to the elevation and development of the individual, and only secondarily to a greater material prosperity. It is, doubtless, through a mistaken notion that the trade school does not do this, that this class of schools has made so little headway in this country. If we teach a boy a trade it is not only that he may practice it, but that he may become a master workman, an employer, a contractor, a manufacturer, a proprietor, a leader in his calling, and withal an influential citizen and a participant in public affairs. That a properly conducted trade-school would lead to these results in this country cannot be doubted. We should teach our boys many things besides the mere manual performance of a trade. In the trade-school should always be taught some of the scientific theory which accompanies and underlies such performance. It is not necessary, however, to teach all these related subjects in the trade-school. We shall continue to rely upon the public schools for the general education. The trade-school with us must supplement this, and not displace it. It remains for us to work out a system of trade-schools suited to our needs.

The need for industrial training in the various practical vocations and trades is becoming daily more apparent. Not only are most vocations becoming more scientific and less traditional in their practice, but the wholesale introduction of labor-saving machinery and the abandonment in large measure of the apprenticeship system, leaves our boys and young men almost without opportunity or resource in entering successfully any of these practical callings. In addition to these inherent obstacles, the rules of the trades unions by which the admission of learners is limited to a very insignificant number, still further shut out young men from all lines of productive employment. In very many cases not even the proprietor's son is allowed to learn the business practically, or if perchance the permission of the union be extended to him to enter the works as a learner, he must beware of his steps, for pitfalls may be set for him at every turn and sometimes even his life may be in danger.

It has come to such a pass, in fact, that the avenues by which American youths can learn almost any practical calling in all its details are often absolutely sealed up. The only recourse is the teaching of all these trades and employments in especially equipped schools. If the would-be apprentice hopes to become anything more than an average workman, he must learn the scientific and practical elements of his trade somewhere, and it is well established that he can learn them most successfully in properly operated schools. These schools should not individually attempt to teach too much; they should, however, teach the underlying scientific principles of one or two trades thoroughly, as well as the most improved commercial practice. The practice, however, is the most difficult to teach in the school. In the first place it is hard to find persons having both the practical knowledge and the teaching ability. To impart practical knowledge rationally one must rest it on some scientific or rational basis, and not simply upon the dictum of tradition. This rational basis of trade practices is commonly either entirely wanting or if it exists at all, it is quite unknown to the practitioner. His reasons for his doing a thing so and so are usually far from sound. Competent instructors in the practical trades are, therefore, very difficult to find.

In spite of all these difficulties, very efficient trade-schools are established and others are called for by the proprietors and managers of various industries. At the last meeting of the American Foundrymen's Association, held in Chicago, June 5–7, 1900, a resolution was adopted calling for high-grade industrial schools to teach the science and art of founding. The school in clay industries started a few years ago at the Ohio State University has already resulted in the establishment of new ceramic works of very great promise; as a rule the expense of establishing and maintaining these schools should be met by industrial corporations, or by individuals, or by the joint action of manufacturers, locality, and State. Some of the more important industries now requiring such schools will be named.

1. *The Textile Industries* are among those which

most readily submit themselves to monotechnic or trade-school instruction. Trade schools in these industries have long been common abroad, and a most successful one has been in operation for many years in Philadelphia and one for a shorter period in Lowell, Mass.; a number of new ones have recently been established in New England. The State of Massachusetts makes a standing offer of $25,000 assistance to any city or corporation in the establishment of a textile school which complies with certain requirements. In the higher textile schools, the science of dyeing and the art of designing are taught as well as the practice in weaving and finishing all grades of fabrics. These higher courses are several years in length, and are best pursued after taking a high school or manual training school course. Even a college or an art-school, or an engineering school preparation, before one enters the textile school, is none too much if one wishes to fully master the industry, to understand mechanical and the power plants, and also to become familiar with the business departments of the manufacture and the sale of textile fabrics on a large scale. Many of the highest and latest developments of the science of chemistry find their application in the dyeing of yarns and fabrics, and the large dyeing and printing works in Germany have many chemists constantly engaged in studying new and improved applications of chemical knowledge to the textile industries.

2. *The Machine Trades* are at the basis of all manufacturing, and superiority in these very largely sustains our modern national prosperity. The fundamental

principles and most of the practice of these industries can best be taught in schools having proper equipments. Formerly a great deal of hand-work was done, and every journeyman in the shop was expected to be able to perform any task in the ordinary routine of shop duties. This demanded a long apprenticeship in actual shop-practice and the acquisition of a high degree of manual skill. The recent general introduction of automatic and labor-saving machine tools. and also tools of extraordinary size, has, however, created a demand for an entirely new class of workmen. Now the average workman in our large shops is only a machine attendant, and he is kept employed with a single class of machine tools. His business is to learn the capacities of these tools and to get the most work out of them of which they are capable. In fact some of our most progressive superintendents affirm, that they prefer these narrow specialists to the old fashioned all-around machinists. For a tool attendant of this class very little general training of any kind is required. With good instruction he will learn in a few days, or perhaps hours, to operate a machine intelligently and very soon he will be working it to its full capacity. Trade schools are not a necessity for these men. This system carries in it. however. the seeds of its own destruction. By this system no one man is learning the business in its entirety, and hence no one is being trained to superintend or manage the business both theoretically and practically. The graduates of our colleges of mechanical engineering would make the most capable men for these higher positions of superintendence if they could be given an opportunity, after leaving the schools, to learn all the practical details of the business. It has not been possible hitherto to secure such men in sufficient numbers. On the one hand the managers of works have not been fully informed as to the benefits of such a course, and on the other the graduates of our schools of mechanical engineering are not always willing to begin at the bottom to learn the business. Failing of these the graduates of our manual training schools would serve very well for these positions of trust and supervision. These are more ready to enter the lower ranks of mechanical employment and work their way to the top. By a special kind of apprenticeship in the shops, some of these young men would rapidly develop into very good foremen, superintendents, and managers. In many cases, however, the trade unions would seriously interfere with any free application of this sort of a program.

Again it must not be forgotten that many of our most ingenious and capable machinists and mechanical inventors who have become the proprietors of the finest machine-tool works in the world, have had no special technical education, but have come up through the old system of apprenticeship. To save this class of talented young men to the business, and to enable them to more fully master an industry now that the apprenticeship system has been practically abandoned, some means should be provided for giving them what the former system gave, and which the technical and industrial schools are giving to their students. These men will not leave their employment and go back to the schools. Such schooling as they are ever to receive must be brought to them. It is probably true that many of the most capable of this class will now find some means of acquiring a technical education before entering upon industrial employment, whereas formerly apprenticeship was the only way open for entering these industries. It is probable, therefore, that only a few of the untrained workers in the shops to-day will care to avail themselves of any school opportunities, however convenient, but these few are the ones who would profit most by such training, and whom society can least afford to lose from its high service. These may, with some technical instruction, become leaders and directors of their fellows, and founders of new industries, and the rest may remain automatic attachments to their mechanical tools if they choose, without seriously impairing the success of the works and the local and general prosperity resulting therefrom. This is the hardest, though not the largest and most important, problem your committee has had to struggle with. How are we to furnish adequate instruction to those young men who will have had no opportunity to secure a technical training, but who, after entering upon some industrial calling, wish to remedy this defect of early education? Such answers as we are able to make are contained in the next section of this progress report. Since nearly all industrial production to-day is mechanical, the solutions which are offered for the technical training of machinists will apply very largely to the workers in all lines of mechanical production.

VI. SUPPLEMENTARY SCHOOLS FOR INDUSTRIAL WORKERS.

These are schools for those bright and promising boys and young men who have from choice or from necessity already gone to work in some industrial calling with little or no scientific or technical schooling, as well as for those boys who can be reached by no other class of industrial or technical schools. The present demand for these supplementary schools is very large, but with the general introduction of manual, scientific, and art education, into the public schools, the demand for such supplementary schools will be very greatly reduced. The most promising foundations for the organization of these schools your committee believe to be the following :

1. *Proprietary trade schools in connection with industrial works.*—Nearly all lines of production are now organized into a few great manufacturing centers, and all the factories of any one class in the whole country are more than likely to be operated by a single joint stock company. This company shapes the industry over the whole American continent. We believe that it will be profitable in all these great industries to establish industrial schools in connection with all their large factories in which a few of their brighter workmen can be educated not only in all parts of their business but in the underlying and related sciences, in order to become capable foremen, superintendents and inventors. These are at least a considerable proportion of the men to whom the stock-holders must look for continued improvements, for skillful management,

and for economic operation. After we have passed through the stock-jobbing stages of these new and mammoth combinations, we shall surely come around to this basis of most economic production and safe business management. The machine attendants will commonly be taken from the ranks of unskilled labor. These can be taken on and put off at pleasure, and they will be found in that large class of happy-go-lucky individuals who find self-improvement too laborious and confining, and who feel that sufficient to the day are both the good and the evil thereof. In those industries where perfection of workmanship is a prime essential, even the machine attendant must be a bright, skilled, thoughtful, attentive man or woman; and in these works some educational stimulus and some rewards for acquired skill and for fertile suggestions will be found to be not only fair dealing but a most profitable business policy. We are now passing rapidly through an evolutionary if not a revolutionary stage in these matters, and our general managers of large works are coming to realize the necessity of an educational side to their business. It is said of Americans that they are quick to see opportunities of improving their business and are ready to adopt any measure which promises a sufficient return for the outlay. Your committee feel that these proprietary schools in connection with industrial works will make their own way in this country without any organized campaigning, but some systematic effort to present their advantages will hasten their general introduction. Whether these schools take the form of night schools, of half-time day schools, or of financial aid to the brighter lads to attend some specific courses in a technical school, or all of these combined, is not now material. That all of our large industrial works and combinations of works should be brought to see it to their interests to furnish supplementary school facilities to their brightest boys, is the problem which now presents itself to those who wish to further the course of industrial education in this country. It may well be that many manufacturing establishments will find it to their interest to work in conjunction with a correspondence school as described in the next section. Railway corporations, and large mechanical, electrical and chemical manufacturing companies, will probably draw all their technically trained men from the regular engineering schools in preference to establishing technical apprentice schools. These are then given a few years of systematic shop and laboratory experience, which serves as their industrial apprenticeship. Some of our railway companies, however, are introducing elementary apprentice school instruction into their large construction and repair shops.

2. *Correspondence Technical Schools.*—These have sprung up like magic in America in the past ten years and are now thought by many to be serving a great need. Whether they will remain in demand, or are only a passing phase of educational opportunity, may be a question. Until other opportunities of acquiring a technical training become practically universal, however, it is very clear that they will find a great work to do. The fact that a single one of these schools (the oldest one) is now carrying on its roll of students over two hundred thousand names, is the best proof in the world

of the great demand for technical education. These schools supply their students with specially prepared texts and have systematic correspondence methods of imparting instruction. If the student is willing to do, his part he may obtain in this way a very fair substitute for a school training. He lacks the stimulus, however, of a direct personal contact with a teacher and with other workers in the same subjects. This advantage can be partly supplied by a little encouragement from employers. Some establishments are now supplying rooms, fitted with drawing tables, warmed and lighted, where the correspondence school students, amongst their employés, can spend their evenings in study. Where the numbers are sufficient the correspondence schools may eventually find it to their interest to supply local teachers. This would vigorously supplement the work of the correspondence school where it is now weakest. The entire absence of laboratory and shop instruction in correspondence courses, however, is a serious disadvantage, particularly in technical instruction.

An overwhelming majority of the students who begin these correspondence courses become discouraged, or find themselves overburdened, or else have not the requisite application, and so stop work in the early stages of their correspondence courses. This is not surprising when the persistent, systematic and seductive methods of obtaining subscribing students are fully understood. Still the truth remains that if a young man really wishes a technical education and is willing to do his part, he can get a great deal of elementary assistance in this way, be he in the slums of a large city, or on a cattle ranch in Texas, or in the South African gold mines. And these necessities of the isolated learners will probably always make a large demand for correspondence instruction, no matter how general other means of acquiring a technical education may become. These schools are but another evidence of the quick initiative of Americans. The demand was no sooner felt than the supply was forthcoming in this new and original kind of a school. Such schools, however, can never supply the place of any of our regularly organized and equipped day, or even of our evening, technical schools.

3. *City and Endowed Evening Schools.*—These are designed to serve young men who are employed throughout the day. They are quite similar to such schools abroad, most of the so-called technical schools of England being of this class. The student comes two or three evenings a week from seven or eight to ten o'clock. He comes more or less worn out by his day's toil and he reaches home long after his usual retiring hour, practically exhausted. His mind cannot be alert with his body in a fagged-out condition and hence this class of instruction is at once a great hardship and, in comparison with day schools, it is of relatively little profit. Men who are engaged in any kind of actual manual labor through the day are greatly handicapped in their attendance upon such schools. They are most valuable for clerks, bookkeepers, draughtsmen, and the like. They can never become a very substantial element in the technical education of the industrial classes.

But besides the inherent weakness of these night schools, we find that many of them are not well taught. The teachers are changed from year to year, and there is no fixed policy or line of study. The teachers, also, are not commonly experienced in imparting instruction, and the whole atmosphere of these schools, especially in our city evening schools, is apt to be very far from stimulating and invigorating.

4. *Y. M. C. A. Evening Schools and Sunday Technical Schools.*—The Y. M. C. A. evening schools are now being organized under a competent central supervision and are pursuing fixed courses of study under much more competent and continuous instruction than formerly. These schools now instruct some 26,000 students in the United States, with a high average attendance. Their finishing certificates are accepted as evidence of sufficient preparatory work in about one hundred institutions of college grade. Notwithstanding this proof of the great importance of these schools, their work is more with the mercantile than with the manufacturing classes.

Sometimes Sunday technical schools have been tried but they are not likely to be very largely introduced or patronized in this country. Professor Woodward, who tried for four years in St. Louis the experiment of a "Sunday morning technical school," is of the opinion that such schools could be made very successful if properly equipped and made permanent in any industrial community; but an American community must first get used to the idea.

These supplementary evening and Sunday technical schools, therefore, can never serve as an adequate means for giving to young men in America a high technical development, or in preparing them for a great technical service to the manufacturing industries. They are the only resource for a large class of wage earners, and they should be encouraged and well supported, but they are at best a poor substitute for day schools, and they cannot be regarded as anything like an adequate means of self-improvement for our industrial workers. They are more efficient, when properly conducted, than the correspondence schools, but they cannot reach the isolated student as the correspondence school does. Where the evening school is available, as it is in all our larger cities, it should be preferred to the correspondence school.

5. *Half-time Self-supporting Trade-Schools.* — This class of schools has recently been ably advocated by Mr. M. P. Higgins, in the Proceedings of the American Society of Mechanical Engineers. Mr. Higgins was for twenty years in charge of the shop instruction given in the Polytechnic Institute, of Worcester, Massachusetts. He states that the experience of that institution justifies the claim that well-equipped and officered industrial works, as for instance large machine-tool or engine works, joined to good technical schools, could be made to pay a very large proportion if not all of the shop expenses. In such a school the boys would spend half the day in the school and the other half in the shop. They would pay little or no tuition but they would receive nothing for their work. The school would be divided into two sections and these would alternate in school and shop work. A sufficient number of expert machinists would be regularly employed to oversee the shop work of the boys

and to impart the shop instruction, while the theoretical or school work would be given also to both forenoon and afternoon sections by another set of technical instructors. In this way very nearly actual shop conditions could be introduced and the advantages of the old apprenticeship system could be retained in addition to the further benefit of a regular school training. If such a system of trade schools be practicable they may go a long way towards furnishing a final solution to the great problem of the industrial training of the rising generation. It is to be hoped Mr. Higgins will find the means of embodying his ideas in an actual combined shop and school as he proposes, and so proving the practicability and efficiency of his plans by an actual test. For such a trial the most favorable conditions should be secured, the most competent instruction obtained, and the best possible shop equipment purchased. It is vitally important that the first trial of such a plan should be given every fair advantage to prove its worth. If it succeeds, as its chief advocate promises that it will, it may mark the beginning of as great a movement in industrial education as the manual training school has done in general education. There is no middle ground between the expert machinist and the mechanical engineer. The difference is one of degree rather than of kind. These half-time schools would turn out expert machinists, many of whom might become skillful mechanical engineers. Your committee fear, however, that in some localities the opposition of the trade unions would prove fatal to all such schools engaged in regular manufacturing.

6. *Public Libraries and Scientific, Technical, and Trade Journals.*—We must not forget that every man who has come to anything is almost wholly a self-made man. This is particularly true in America, and applies to mental as well as to material acquisitions. The mental atmosphere which pervades our great industrial works is always bracing and sometimes stimulating. If free public libraries are not conveniently available, a free proprietary library and reading-room at the works can readily be established. Here all the current technical and trade journals can be kept on file, and those employés who are capable of a large development will find here their mental nourishment. It is, we think, not too much to say that in almost every industry there are now books, technical and trade journals, and catalogues of a very high educational value, which can be continually added to at a small cost. If these reading-room facilities are wanting, therefore, any ambitious boy or man can take one or more of these journals, and by studying them and a few well-selected books, he can acquire a very fair scientific knowledge of his calling. A generation ago these also were almost entirely wanting, so that then, with neither schools, nor books, nor journals, the only possible means of acquiring a knowledge of any industry was through a long apprenticeship in the business itself. But now, if both the systematic apprenticeship and the technical schooling be wanting, there still remains a flood of printed matter in books and journals from which a young man can, if he will, obtain a very fair theoretical grounding in the manufacturing or commercial industry in which he is engaged.

VII. HIGHER COLLEGES OF COMMERCE.

These are common upon the continent of Europe, but have never obtained recognition in England or America. They are now being strongly urged upon our people, and a number are likely to be established in the immediate future.* In these a full four-years' course of instruction of college grade will be given. The work will include a writing and speaking knowledge of one or two foreign modern languages; a wide acquaintance with commercial geography and the materials of commerce; full courses upon means and methods of transportation, and the shipping regulations of various countries; commercial law and customs regulations, both foreign and domestic; the laws and practices of banking and exchange: political and economic science; mediæval and modern history; the history of commerce and manufacture; consular duties, regulations, and reports; international business law; and other subjects which can be taught, and which will help to qualify a young man for a responsible position in a large business having foreign relations, or as a United States Consul. It will be to men having such an education that we must look for a successful competition with Germany in our foreign commerce. But we have already seen the necessity for these schools, and we may confidently anticipate their rapid and successful establishment. We must guard against making the mistake of merely grouping together a series of subjects now taught in our schools, and calling that "a course in commercial education." The work must be technical, and immediately available and useful, rather than general and cultural. The subjects must be taught, therefore, in a way quite different from that employed in our literary colleges. This will require separate class organizations and very largely separate instructors, when the school of commerce is made a part of an existing college or university. These schools will, therefore, be expensive. There should also be in connection with every such school a well-equipped commercial museum, in which are kept for examination and study nearly all the ordinary articles of commerce in both the raw and the manufactured state. These schools would then stand in a supplementary relation to the higher industrial and engineering schools. While the latter train the captains of industry, the former train the men to exploit the products of these industries in all foreign countries. In the development of our foreign commerce one is as essential as the other. With both, our material supremacy is assured for all time.

---

*Such schools have now (Oct., 1900) been established in the University of the City of New York, in the University of Pennsylvania, Philadelphia, and in the University of Wisconsin, Madison.

The above is offered as a hasty and provisional review of the field of industrial education in America, and as a progress report of your committee. The committee has had to do all its work by correspondence, several of its members being out of the country at the time of this meeting. If the society decides to continue the committee, they will try to make a more mature report, with recommendations, at a later meeting of the society. To assist them in their work they hope to secure at this meeting a general expression of the views of the members, and of others who are exceptionally well-informed in these matters, and whom the committee has invited to be present at this session and to participate in the discussion. The duties of the committee are not clearly defined, but we have assumed them to be: the critical analysis of existing and proposed methods of industrial education at home and abroad, and the endorsement of those which seem to be best suited to American needs.

Respectfully submitted,

(*Signed*) J. B. JOHNSON,
C. M. WOODWARD,
R. H. THURSTON,
H. T. EDDY,
GEO. F. SWAIN,
EDGAR MARBURG,
Committee.

DISCUSSION.

PRESIDENT MENDENHALL (by letter) stated that he had read the report on Industrial Education with very great interest. He expressed regret at not being able to be present at the meeting this year to take part in such a discussion as it might call forth. He thought that the committee had made an extremely interesting and important report and that, in the main, he could subscribe cordially to every proposition. The principal danger which has to be confronted in this matter, and which apparently the committee has fully recognized, is that of magnifying the importance of what we may call the materialism of the twentieth century. Every effort seems to be pointed towards training young men and young women to acquire wealth, and this necessarily means less attention to the cultivation of those finer qualities that contribute, after all, more to the happiness of this life. However, this is a very large subject and no doubt it has received the committee's careful consideration. His own desire would be to guard very closely the real functions of the public school, which are considered by him not to include training for special occupations, but rather the preparation for citizenship, which is apparently so much lacking in these days.

MR. H. G. PROUT* said that there were two objections to the theory of special training or industrial education, one of them being that it will divert young men from following carefully and thoroughly the broader and more complete education which they would get in the technical and classical schools now established. A certain number of young men would be diverted, probably, because they could get more easily a certain kind of education which promises quick returns. This perhaps is not a very important point, because for every young man diverted in that way there would be two or three or a half dozen young men who would be tempted to take this industrial course who would otherwise get no education beyond that given in the high or primary schools. As to diverting the young man from following out the more liberalizing courses at the classical schools, the speaker was not so confident of the harm of that as he used to be. It seemed to him that the term "liberal education" may be translated into "vague education," "ineffective education," and that there should not be so much superstition about this liberalizing education, while a little more is done toward training young men toward some actual, precise end. And, after all, that is also a very good liberalizing education.

---

* Editor of the *Railroad Gazette*.

Another objection which we will hear raised to this kind of training, is that it will turn out upon the world many young men and young women who really think that they are fit to do something, and who are so far artisans spoiled, and have stopped short of being engineers, or whatever else is chosen. That is all true, too, but that charge is brought against all schools; and, furthermore, it is not a very serious objection in this country of ours, where effectiveness is a matter of course, and where the ineffective man disappears pretty promptly, or finds out that he is ineffective. Of course, the committee are absolutely right in saying, as they do, and bearing down upon the point, that the main thing for all who are instructing is to continue to open up channels by which somebody will be educated who is not now definitely following any channels; that is, to open up a variety of ways of doing this thing. The great difficulty has been the belief that human history began with the Declaration of Independence and that the capacity to do something then descended upon every American. If in any way the necessity for precise training toward definite ends can be urged upon the people a great deal will have been accomplished. Therefore it seemed to him that the whole movement should be encouraged.

The speaker supposed that probably he was expected to say something as to what the railroads have done. He replied that, as a matter of fact, they have practically done nothing in this line. About twenty-five years ago the Lake Shore Railroad started four schools for apprentices, but they were night schools and open to the recognized objections. Only here and there would there be one select fellow who had unusual ability and good physique, who could do anything valuable at it. The Michigan Central also started something of this sort. They have several schools where they teach the boys something; they teach them drawing and simple mathematics, and try to give them a point of departure from which to go on and make master mechanics of themselves if they have the ability.

The Baltimore & Ohio went into an ambitious scheme of this sort, which collapsed with the failure of that company. A good school of this sort that is closely allied to the railroads is that of the Brooks Locomotive Works, established in 1883 by the public spirit of Mr. H. G. Brooks. They have quite a liberal method of helping their boys and the sons of men employed in the works, and it is believed to be doing a great deal of good.

In conclusion, the speaker wished to add that, during the last three to five years, it has been his good fortune to see a good many of the engineering colleges of the country, and that he was amazed to see the splendid work they are doing; it has been a liberal education to him. They are doing a grand work all over this country in the way of bringing up young engineers, and the effect of this work upon our country in the next fifty years is something that none can conceive or exaggerate.

Mr. M. P. Higgins said that this report, so ably and clearly covering the field of industrial education, was of special interest to him, and that he had read it with keen appreciation and great profit.

He believed that educators, engineers, and manufacturers will generally agree that no more important topic of education has ever been before the American people than the consideration of the future and immediate schooling and training of mechanics and workers below the grade of engineer, who are to carry on our manufacturing and mechanical industries. By "mechanics" he meant all who are engaged in the production of things useful.

The country is not likely to suffer through the lack of the highest scientific knowledge and ability of American engineers, but one cannot speak so confidently regarding the rank and file of our workmen, machinists, etc. This lack of confidence exists despite the fact that American boys are superior in native ability, in skill, method, and invention; and this lack is solely because no adequate effort has been made to bring the best boys into the trades, or to train them so that our country can hold the supremacy in machine building, in manufacturing and in other lines of industries.

The common-school system seems to be nearly perfect for taking the boys up to the high-school period, but from this point up to the engineering schools the great masses of our boys who ought to be trained as superior, thinking mechanics are drifting aimlessly, and our shops and factories are being unsatisfactorily filled by foreign-born boys, whose mechanical ability is not equal to that of our native boys.

It is evident, in the great industrial battle for future supremacy, under the inevitable system of intensified production, that our best boys with the best possible training will be needed; but, aside from this necessity, there is no field so promising and attractive as this for an unlimited number of educated, skilled workmen.

In our common schools there is the important element of manual training, but this training, as the committee truthfully says, makes no pretense of fitting boys for particular employments. There must be training schools for special employments, a training in skill and experience that shall be braced or supplemented by a good, liberal education and a degree of culture, such as will develop the individual and attract our better talent into mechanical work. All this is possible by the co-operation of educators and business men in organizing a suitable system.

President Tucker says that the next advance in education must come from without the schools. The speaker thought it better to say that it will come through the co-operation of those without and those within the schools.

The mechanical schools, engineering colleges, and State universities have been so successful that they have gone above the needs of the people for industrial education.

The committee has said: "While the original purpose of the national appropriations was doubtless to train young men for actual practice in scientific farming and in other industrial pursuits, the students from these schools hitherto have very largely developed into civil, mechanical, and electrical engineers." They have not, therefore, fulfilled the hopes of their founders. This is because the working mechanic is not reached by these schools, and the speaker deemed it the object of this report to find a plan to give this important force of mechanical workers an education; a training and a degree of culture commensurate with their needs, and commensurate with the imperative, future needs of the mechanical industries.

The report says: "The machine trades are at the basis of all manufacturing, and superiority in these very largely sustains our modern national prosperity." The speaker thought this to be true; and he wished that he had time to show the comparative importance of the machine trades and why this must be the basis of all industrial training.

Then comes a part of the report which he thought was wrong, or at least, misleading. It reads as follows: "Now the average machinist is only a machine attendant." In fact, the machine attendant is not a machinist at all; and a machinist is not usually employed as a machine attendant though he could do it much more effectively and it might pay to employ him if he were available.

It is a great mistake and one that no person must be led into, to suppose that intensified production by modern methods (by automatic machines, piece-work and what not), does in any way reduce the demand for the skilled machinist or the high quality of his skill. No, it increases the demand and positively advances the requirements for his skill, as well as for his scientific and technical knowledge.

In referring to the machine operative, also, the report says: "Trade schools are not a necessity for these men." Now, this ought not to be said; or, at least, if it is done it must be because their needs must be postponed, because the classes ranking as machinists are so much more imperative in their needs and demands for immediate trade-school education.

As a matter of fact, the machine operator even needs an education, and a training, and it will pay to give it to him, and he will have an opportunity to obtain it sometime, provided American educators recognize American needs and American chances for industrial supremacy.

Again, the report says: "The graduates of our colleges of mechanical engineering would make the most capable persons for these higher positions of superintendents if they would be willing to enter the shops after graduating from the schools and learn all the practical details of the business."

Now, in general, this is not reasonable to expect. In many cases the graduate thinks he can do better. In most cases he has been educated away from such shop-work for the sake of knowledge; in fact, he is rather too old and advanced for that sort of thing. A foundation can be put under a structure after it is erected, but the best time is at the time of its building.

The speaker wished to assure the educators who are so ably equipped to consider such a subject, that they will be surprised and gratified when they come to gather up all the advantages of real, productive, commercial shop-practice and machine-building experience as an integral part of an educational course. Its intrinsic value is enough to introduce it at almost any cost; its educational value, as a means of strengthening the judgment and disciplining the mind is of equal or greater value.

The report still further says: "The graduates of any manual training school would serve very well for these positions of trust and supervision." * * * "These young men would readily develop into very good foremen, superintendents and managers." But there is a gigantic IF in the way. IF they would enter the shops and learn the trade by "*systematic apprenticeship.*" But there is no "systematic apprenticeship,"—and can never be in our system of American production. Therefore, because the manual training high school does not teach and does not profess to teach any special trade-work and skill, it of course falls short of meeting the demands for a trade-school system.

What has been said in the report regarding night-schools fully corresponds with the estimate of any careful observer. The night-school system upon which England has relied and failed, is entirely inadequate to American needs, and is only a poor crutch to help, save in a few special cases.

The speaker had more hope in the principle of the correspondence system; in good hands and under good control, this system is capable of great results among thousands who want training and who cannot have the benefits of a real course in a trade school. In the city of Worcester, Mass., there are over 1,200 boys and men devoting their evenings and their money to this system. It certainly indicates a desire for learning, even if the plan is not the best one. He said that among his own men and foremen great progress in sound learning is being made with this system.

In this report, there is a statement that is refreshing: "Your committee are quite agreed that in America, every boy should find his career entirely open at the top." The speaker liked that "entirely open at the top." It suggests *upward draft and feeding at the bottom!* In this way the importance may be seen of *vertical circulation* vs. *horizontal stratification.*

Herein lies the greatest hope, our greatest advantage in the industrial world when the great just conflict of competition is fully upon us. The conflict for supremacy through intensified production. But this is a subject for a whole paper, and not merely for a few remarks upon the general subject.

The speaker referred to one more thing in this report which shows the recognition of a fundamental truth. He left the mention of this idea to the last, because he thought it the newest and best. It is as follows: "The mental atmosphere which pervades the great industrial works, is always bracing and sometimes stimulating." Upon this basis he had founded his estimate of the great value of a new and most important feature in our future industrial school system, viz., the shop lecture room.

The idea of the shop lecture room does not confine itself simply to having such a room in the shop building, but carries the idea of teaching much, if not all things, to the pupil in the shop, and while he is at his work, and in intimate, applied connection with his work.

The speaker declared its possibilities to be more than he had time to even mention.

The outlining of such a school plan as published in the *Transactions of the American Society of Mechanical Engineers,** is the result of the speaker's study, experience and observation for the past thirty years. He thought that it is calculated to better meet our American needs than any plan he had found in this country or in Europe. The half-time school is intended to solve the important question in the family: "What shall we do for our boy?" This question arises thus: John is fourteen years old; he has completed the grammar school. If he enters the high school, it means four years more. This is often a very important

---

*Papers by Mr. M. P. Higgins, Numbers 850 and 864. *Transactions American Society Mechanical Engineers*, Vol. XXI.

question. The mother sees that, if John goes to work with a doubtful chance of learning thoroughly any trade, he practically shuts the door against future liberal education and culture. The father is earnest and willing to sacrifice heroically, so that John can go on for four years in the high school, although he does not know what the four years more in school will do for him; and so, in his perplexity, he says: "Yes, John, we can get on, I think, for four years in the high school. You will then be a strong man of eighteen. What will you do then?"

It must be admitted that the answer to this question is not a simple one although it is a very important one. Now, imagine that John is able to say, "Father the problem is solved. The half-time school is now opened. In it I will become a skillful machinist, able to earn more than a living immediately upon graduation and I will also have all the benefits of a high school education at the same time."

The fondest, though hitherto the faintest hope for a broad, liberal, scientific education dawns in view; bright, real and possible without charity or indebtedness; for John will be nearly or quite fitted for the technical or engineering school, which possibly he may enter at the age of eighteen, or after a year or two of money earning in a machine shop. This certainly would be a new and bright outlook to thousands and thousands of homes throughout our land.

Whatever success may be ascribed to the present methods of technical education, the speaker was confident that all who will study the subject will admit that something else is demanded; a system that will reach the greater number of our sons who should become working mechanics. This greater number can be reached by the proposed half-time school; a system that is recommended and urged because it will not conflict with present good working systems, because it will not duplicate the present common school system, but will supplement it in a most practical and economical and effective way. And by this system it is confidently hoped to avoid what is the most obvious danger, viz., a failure to enlist and hold our better American youth to our mechanical and manufacturing industries instead of allowing these industries to fall into the hands of others less able to advance them.

PROFESSOR JACKSON said, in regard to the question as to whether engineering colleges founded under the Land Grant Act have really done their duty and fulfilled the expectations of their founders, that he thought that the engineering college in the University of Wisconsin might be used as a type of the western colleges, and that he had, two or three years ago, looked up the statistics in regard to the young men attending the engineering college, and he found that about one-third of their number came from farmers' families, one-third from families of artisans and one-third from the families of professional people. It, therefore, seemed to him that, as far as the giving of education to the sons of farmers and artisans was concerned, the engineering college of the university had done and is doing its share. The probability was that other institutions in the west are also getting an even larger proportion of their students who study engineering from the families of farmers and artisans.

As far as his own observation went, the young men who have come from the families of farmers and artisans have very soon taken a position in the world in general, and industrial life in particular, of which their parents may be very proud; and there, again, he thought the engineering colleges had not failed in their duty.

The speaker wished to add that he was in full agreement and sympathy with all that had been said with respect to the desirability of doing much more for the artisan class, and especially in the training of first-class machinists and artisans who expect to remain in that class, just as many of the state colleges are doing much, through special short industrial courses, to train the farmers' sons as farmers.

Professor R. S. Woodward said that it appeared to him that this report makes an era; that, as far as he knew, it was the first report brought to his attention that distinctly recognizes that there may be many kinds of education. Many will remember that, thirty years ago, there was only one kind of education that was recognized. Men who had been educated in the school of experience, from which there are no graduates, were looked down upon, and yet to-day the authors of the report under discussion have directed special attention to the names of two individuals who are not college graduates, but who will be admitted by all to be very highly educated men.

Another point which struck the speaker as remarkable, is that the authors of the report are willing to recognize that there is more than one kind of liberal education. A few years ago it was thought that there was only one kind of liberal education, and there are a good many people to-day who assume to be able to draw the line very definitely between what is liberal and what is illiberal education. The speaker remarked that during the past two or three years he had met these people, and had sought to determine what their definition of a liberal education is, and, as far as he could find out, it is this: "The sort of education I have had." And the man who uses this definition is the man who has had a classical education. Certainly it is not to be said that the classical education is not eminently valuable and to be commended, but it is not well for any kind of education to secure predominance, and the splendid thing about the report under discussion is that it recognizes that there may be various kinds and degrees and forms of education in our own line which are all good as far as they go. It is a great thing to be able to admit that fact in this Society. Of course, as to the details of the report, the time is not long enough to discuss it, but the speaker trusted that the report would not only be published by the Society, but that it will be distributed far and wide, because it is a thing which could not emanate at the present day from any other Society in the world. It is one of those things which had long been looked for, and now it is at hand. It should be circulated far and wide.

Professor Ayres mentioned one phase of the question brought to his mind, which he thought was a very difficult phase. The type of a liberally educated man which Professor Woodward presented, and who defines liberal education as the sort of education he himself had received, is familiar to most persons engaged in college work. The speaker thought that the greatest hope for a true view of education is in the continually increasing prominence of engineering and scientific work in the universities, and he merely stated this in order to bring out the idea that in the development of any phase of education in the future it would seem to be of the greatest importance to keep all kinds of education together. He thought that the technical school, separated from others, a school dealing with a specific subject or profession, is a bad thing from an educational point of view, because, although culture studies may be introduced in such a school, with the idea of producing a greater or less approximation to the conventional liberal education, not nearly such good results are attained as when different classes of students are pursuing the work together and coming to realize, by contact with fellow students who are working in different lines, that good men are studying engineering, good men are studying chemistry, and good men are studying Greek, and that real earnestness of purpose and desire for learning are limited to no special class. It seemed to him, therefore, that, in directing the future trend of education, the fact should not be lost sight of that, while it is desirable, by the best special training, to help the community, the development of the *man* should not be lost to view. The best way to accomplish both objects is to get just as many as possible of the educational forces to work together, and to enlarge upon the type of institution which we have, rather than to build up new types. The speaker acknowledged the importance of the class of schools pointed out by Mr. Higgins, but he decried the tendency to build up special schools. That the real American university is well typified in Cornell, Wisconsin, or Columbia University, where the highest results of liberal education are accompanied by the highest results of scientific and technical education. It seemed that the student who comes at once within all these influences is educated most effectively.

Mr. Richard P. Rothwell* wished to express his admiration for the report which had been made, and proceeded to speak about Correspondence Schools. One of the most important parts of the education which an engineer receives, is the employment of his material where it will produce the maximum useful effect. The education which produces the greatest effect in the aggregate is the education for the masses, for the artisans and workers. There is, of course, no comparison between the numbers who are comparatively uneducated, and those who are able to follow the higher branches of engineering or mechanics. The masses, the artisans and workers, are not able to attend schools after they have passed through the public school; their first object is to earn their living by work in some useful occupation; and they find this to be so engrossing that they usually have no opportunity to study where they have the desire to do so. How to reach these people, how to make them more efficient workmen, and through them to benefit the entire industrial position of the country, is to my mind the greatest problem of the age. There is no question that the greater intelligence of the working classes, the higher will be their efficiency and the better and cheaper will be the product of their labor. The quality and economy of the products of industry are the foundation of national prosperity, and, therefore, it is desirable to commence with the education of the artisan and the mechanic.

---

* President of the United Correspondence Schools of New York.

There is nothing which so interests anyone as the occupation by which he earns a living. If one can show a man that if he does this or that, he will be a more efficient worker and will earn a larger income from his labor, it will have a direct interest for him that no urging, which he may get in the general school or college to acquire abstract information or knowledge, will ever have. It is one thing to say to a young man : "Now, learn this, for you will probably need it one of these days"; and another thing to say to the man at work, "learn this and you will be more efficient and will earn more wages." There is no doubt that if the proper means are brought to the working classes of the country, a greater useful effect will be produced than by educating the higher classes, while, of course, nothing is to be said against that. The speaker remarked that he had the good fortune to study engineering in the best schools of two continents, and appreciates this fully. Yet when it comes to the question of producing the maximum useful effect with the means at command, greater results can certainly be secured by educating the masses than in educating the small number in the higher departments of engineering.

The correspondence school has one of the objections that have been pointed out, that it is a money-making institution, but this does not appear to the speaker to be a drawback. It is well known that when one undertakes to furnish something that people may take or leave, if he does not give the worth of their money he will lose his own, for people will not buy his goods. Now, the fact that a correspondence school is under bond to the amount of its investment to furnish value for what it gets, and will lose its investment if it does not, is certainly a strong guarantee that it will furnish more useful information than will the endowed school which furnishes free instruction, and that goes on whether it hits the mark or not. There are not a few of our large colleges whose courses are designed by gentlemen of great learning but who have never had to earn their living by labor in the occupations they are teaching. These gentlemen evolve more or less from their inner consciousness what a young man or woman should learn, and not infrequently when these young people get out in life and have to earn their living they find that they should have learned something very different. The best way to know what ought to be taught in any subject, is to go to the men who are earning their living in that occupation and ascertain what will enable them to earn more. Teach them what will make them better workmen and able to earn higher wages. When you begin here, and work from the bottom up, I think it will be almost as much more efficient as the heating of water from the bottom up is more successful than trying to heat it from the top down.

The correspondence school is founded upon supplying the needs of the people who are taught, and any occupation can be taught by correspondence. It says to the workman, "if you knew more about your work, if you studied the reasons for what you are doing, you would be a more efficient worker, and you would be worth, and would receive, higher wages. Here are the means of acquiring that knowledge, it will cost you but little and the payments are so distributed that they are easy to make, even for the low-wage mechanic."

I firmly believe that what men get for nothing they value lightly, and that where they have free schools they do not profit by them as if they had to pay something for their education. The speaker declared that, a short time ago, a gentleman who is much interested in educational matters, said that he would like to devote a certain amount of money to free scholarships. He was answered: "Sir, we don't want them. If you will establish prizes for the student who makes the most progress in a given time, that is another matter; but our experience is that a free scholarship does not make a good student."

The teaching of the industrial classes is not difficult, if one commences at the right end, by getting down among the workers and finding out what is actually needed to make them more efficient. With women the first essential is housekeeping. No class of mechanics ever struck for an advance in wages that, if they gained it, would have been nearly as important to them as it would be to have their wives and daughters taught how to keep house. Here is one great field for a correspondence school, for these women cannot go to school; but they can learn by correspondence how to keep house.

The methods of teaching should be adapted to the people taught. The speaker doubted whether the very learned and able gentlemen who are teaching in Columbia University, and there are no better in the world, would at all make a success of correspondence education. To do this one must understand the people who are being taught. The secret of success is to find the men who can teach the industrial classes. These teachers should have been brought up with them and have learned how to teach them; should have, as it were, their range and be able to hit them.

The courses of most of the correspondence schools are good, some of them better than others, and all are bound to be, in the future, a great deal better than they are now. This is a very new departure, and yet the correspondence schools of this country, which were started yesterday, as it were, are teaching more students to-day than all the universities of the country. He said that the particular school with which he is associated, The United Correspondence Schools of New York, has already far more students on its rolls than has Columbia University in all its departments; and yet it is but just beginning. No one would pretend to say that the education of the correspondence school is as high as that of some other schools, but each is adapted to its environment. The correspondence school commences with the assumption that the student in many courses knows only how to read and write. The instruction papers are prepared in direct, simple language, and are very accurate, for, with students by tens of thousands, each one of whom wants to know why, the answering of questions that a small number of errors would bring would swamp a school. The aim is, therefore, to have everything accurate. The assumption is that the students are ignorant people, who have studied little beyond English reading and writing, the beginning for nearly all being arithmetic. They go on with a certain amount of mathematics and then branch off into different specialties. If a man wants one line, he is instructed in that and nothing else. The instruction papers are sent to the students after they have paid their first installment, and each paper has a certain number of examinations in it. The students have to answer the questions in writing, and the answers are criticised and returned, with explanations, to the student. The same with the drawing. It would surprise most of the members of this society to see the high quality of drawing done by students at these schools. The drawings given them as models are very well done; the machine drawings especially are done in the very best style.

The method of getting these students, to which the report made some reference, is itself somewhat unique and to some may seem undignified. It is the method adopted by the insurance companies. That is, in addition to the regular advertising, solicitors are employed to secure students. They are of the class of book agents; very glib of tongue and usually quite well educated and are very persuasive. They post themselves upon the subjects taught by the school, and as they get their living by securing students they are ready to convince those they address of the great importance to them of study and the value of knowledge of increasing their earning power. This may be undignified, possibly, but it is a remarkably effective means for spreading knowledge and inducing those to study who otherwise would never do so.

After he has secured a student, the solicitor will keep him studying, because if he does not study he usually ceases to pay his installments and then the solicitor loses his commission. The way this often works may be described as follows: This glib-tongued school "fiend," who persuades the workman that he cannot live or die without the knowledge he has to sell, has to deal perhaps with a fireman on a tug boat, who had not the faintest idea of studying anything before he met this agent. But the agent got him worked up, and the man paid his fee of $2.00 for enrollment. The next month the solicitor comes around and finds that his man has not made much progress, and is disinclined to continue, saying "I cannot understand that, I can't make anything out of it." So the agent whose commission is at stake says, "Why, what is the matter with it?" and he sits down with Jim and instructs him. It is always in arithmetic that the difficulty comes. After the student has gotten over a few difficulties, even the most ignorant student can understand the rest. But the beginning is difficult for a man who has not studied for a number of years. Very many of them find it very difficult, and stop there, but if this number were even larger in proportion than it is, the number of those taught, and those who are induced to study, who would never otherwise do so, leaves the balance altogether to the credit of the system. It may not be dignified, but it is efficient, and that is better. On the whole the correspondence school is, in my opinion, the most important development of modern educational methods.

PROFESSOR ALLEN referred to the comment by Professor Swain (of the committee) to which Professor Johnson had orally referred. Professor Swain had written objecting to leaving the report in the shape representing Professor Woodward as the one who started the work in manual training, as he believed the credit due to Dr. J. D. Runkle. He thought it worth while to suggest that probably Professor Johnson did not have all the facts in his possession at the time the report was written. The speaker said he had in his hand the catalogue of the Massachusetts Institute of Technology for the year 1876–7, which states, under the head "New Department of Practical Mechanism": "A series of shops having been provided for teaching students in the Department of Mechanical Engineering, the use of tools in wood and iron work by the class system, a two years' course in Practical Mechanism has also been established for those who wish to become master mechanics rather than engineers, and especially for the large class of pupils to whom such a systematic training will prove a valuable foundation for further engineering or other scientific study.

"It affords, also, a good English as well as a good disciplinary education, in preparation for any department of life." "This course constitutes a thorough preparation for admission to all the other courses of instruction in the Institute. The shop work is strictly unique, there being, so far as is known, no other school for metal working conducted on the same plan except in Russia."

That was in the school year of 1876–7, showing that a school, substantially the manual training school of to-day, was in operation at that time, and the catalogue further shows a list of students in the course in Practical Mechanism, a list of 22 students. In the President's report for the year 1876, the introduction of the Russian system is taken up pretty thoroughly, and from this report of President Runkle is taken the following extract:

"In all that precedes, I have endeavored to set forth, as clearly as I could, the general considerations upon which this system of shop instruction is based; to show that the solution of the problem has been approached from the instruction side, and not from the construction side, and in this consists its fundamental and thoroughly practical character, as part of the system of education." In the same report is the following extract from "A Report of the Committee on Education," made to the House of Representatives of Rhode Island, at its January session, 1877, by Henry H. Fay, Chairman." Under the heading "Massachusetts Institute of Technology" this report by Mr. Fay says: "In response to the polite invitation of President Runkle, who had been informed of the inquiry of this assembly in regard to industrial education, we spent a day with him, for the purpose of receiving a full explanation of the plan, and of having ocular demonstration of the results thus far achieved. The pupils, since the commencement of the lessons, had completed the course in 'filing,' and we saw in the results of only *eighty hours* of practice and instruction, such exquisite workmanship as could not be surpassed by an apprentice of two years experience in an ordinary shop." "It was easy to perceive that the instruction in this branch of education was as systematic and simple as the teaching of a class in arithmetic or grammar in one of our public schools. Our attention was called to the fact that these shops are for *in*struction and not for *con*struction." "The fact that the instruction is given to so many pupils at a time, in class, is a marked economical feature, carrying out, as in so many other respects, the analogy with our general system of mental training."

"Our space forbids a full description of the many interesting details which came under our observation, as well as any account of the testimony already given by practical and expert mechanics as well as by thoughtful and skilled educators as to the wonderful results already secured in this experiment of an altogether novel method of industrial training, but we are fully satisfied that enough has been shown, in the few months of trial, to warrant us in the opinion that in this well-tried system, at once so simple and so economical, we can find a way to the solution of the great question of the *adaptation of industrial education to our existing system of mental training in the public schools*."

The school referred to clearly existed, therefore, as a school of Mechanic Arts and an important manual training school. The Mechanic Arts High School in Boston does not use the name "manual training," and the same is true of several other cities, and it is probable that Professor Woodward may have been the first to use the term "manual training," but the thing itself is the product of the Russian system, as directly brought from the Centennial Exhibition by Dr. John D. Runkle, President of the Institute at that time; and the speaker, therefore, assumed that to be the beginning of the instruction now pretty generally spoken of as manual training. In the records of this Society, at its meeting in 1898, another historical fact of some interest was stated, it being said that probably the first manual training school was organized by a Baptist church in Georgia. It was, of course, some sort of shop, and it is perfectly true that there was shop work used in schools in this country previous to the time a special system was introduced here from Russia. The speaker said he did not know what was done at the University of Illinois, that matter being new to him, but certainly of great importance in relation to engineering education was the work of the Worcester Polytechnic Institute. It appears, from the catalogue of 1872, that they had then graduated two classes, and they had there what may be called practice shops. They were not understood to be of the particular kind that is generally understood when the term "manual training" is used. If the speaker understood it right, the effort had been made at Worcester that the shops should be practice shops of as perfect a sort as possible; the machinery must be of the best kind, and about 200 students and about 60 workmen altogether work in the shops during the year, so that the work may be carried on, in part, independent of the students, and so that the requisite products may be made even when the students are doing elementary work. It would not have been unfortunate, in the speaker's judgment, if some mention of this important work had been made in the report and credit given to the President at that time, Professor C. O. Thompson, who was afterwards President of the Rose Polytechnic Institute. Mr. M. P. Higgins, present here to-day, was in charge of these shops for a number of years. The speaker said he was not sufficiently informed to know how the credit should be divided between these two. He believed himself to be entirely right in his view of the case that what is now called manual training was introduced in this country by Dr. Runkle, although the name "manual training" was not at that time given to it. It seemed proper to speak of this at the present time, so that the report should not go out in its present form without a proper understanding of the facts.

Professor Allen desired, before taking his seat, to express his high appreciation of the work done by the Committee. All of the members knew that the bulk of the work is necessarily done by the Chairman, and the Society is certainly very much indebted to Professor Johnson for the very able report which he, with the assistance of his colleagues on the Committee, had presented.

Professor White said that, as the introduction of the Russian system was a great honor, he must say a word for the University of Illinois. Professor N. Clifford Ricker saw the Russian Exhibit at Vienna, in

1873, and recognized the value of their method of instruction in shop practice. In the fall of the same year he was placed in charge of the Department of Architecture of the University of Illinois. The University had been giving instruction in machine shop practice under Professor S. W. Robinson since January of 1860, but Professor Ricker did not develop and establish the Russian system until 1875. An exhibit of this work was made at the Centennial Exposition in 1876, for which the University received a bronze medal from the government.

PROFESSOR MAGRUDER reported that he had heard the same story from Professor S. W. Robinson.

MR. KENT said that he was glad to know that it did not depend on him only to destroy the idea that the Massachusetts Institute of Technology introduced the idea of manual training. He thought that credit must be given to the Stevens Institute of Technology for establishing it in '71, and that one of the best exhibits of work of the school-shop at the Centennial Exhition was made by the class of '76 of the Stevens Institute. He thought, however, that Stevens was not the first, by any means, to have manual training as a part of a technical course of study, but that the Polytechnic College of Philadelphia had manual training there then as part of its course earlier than 1870, just as it is now in technical schools. Professor C. M. Woodward introduced the manual training school as a new kind of a school, and not as a branch of a college. It is for the purpose of giving manual training to boys of from thirteen to fifteen years of age, as an adjunct to the general high school training, for educating the hand as well as the brain.

Professor Allen said that in the '76–'77 catalogue for 1876–7, of the Massachusetts Institute of Technology, it is stated that the "course constitutes a thorough preparation to all of the other courses in the Institute," and that it was therefore of exactly the same sort as that Professor Woodward set in action.

It is entirely evident that shop-work was a fact previous to 1876–7, but it further appears from what has been stated as to the University of Illinois and as to Stevens Institute of Technology that so far as the shops were used for making machines as stated by the gentlemen who have called attention to their work, they were not carrying on work of the sort meant when we speak of the Russian system, nor of the sort now largely designated as manual training and which was the outcome of the Russian system.

The speaker again called attention to the statement in the catalogue of 1876–7 that the work was done "by the class system, a two years' course in Practical Mechanism," "especially for the large class of pupils to whom such a systematic training will prove a valuable foundation for further engineering or other scientific study. It affords, also, a good English as well as a good disciplinary education in preparation for any department of life. To be admitted to this course, the applicant must be at least fifteen years of age and must pass a satisfactory examination in the following subjects: arithmetic, geography, spelling, punctuation, English composition, English and American history and algebra through simple equations."

And the point is clearly brought out in the President's report that "the purpose of this school is for instruction and not for construction." It was a preparatory school of the sort that Professor Woodward organized. There was no desire on the speaker's part to claim for the former President of the Massachusetts Institute of Technology anything that did not belong to him. But it did seem clear that Professor Woodward was not the first in the field. It was suitable that the matter should be cleared up.

Mr. Milton P. Higgins reported that the Worcester Polytechnic Institute was opened in the fall of 1868. This was the first technical school in America organized with extensive, well-equipped shops as a department of the school coördinate in importance with the academic work of the classes. This was several years prior to any similar work in other schools. The courses of study and shop work were almost identical with the so-called Russian system as adopted at Moscow and at St. Petersburg. The Russians and the Americans at Worcester were, however, working entirely independently of each other and each without knowing what the other was doing.

In 1876 one branch of the Russian school work was exhibited at the Centennial Exposition at Philadelphia and from what he saw there Dr. Runkle conceived the idea of opening a department of manual training at the Massachusetts Institute of Technology, where filing, chipping and similar hand work was taught to students. I do not think Dr. Runkle claimed to have established anything new and he was able to introduce only one wing of the Russian system, viz.: the elementary part, preceding practice in a real commercial productive shop, the latter being as much a part of the Russian system as the elementary practice. The Worcester school introduced both branches and has always carried them on. But they soon recognized the fact that for engineering students it was not desirable to spend time teaching how to chip and file when it must be the part of the American engineer to get on without chipping and filing by the use of better methods of production.

This was followed by the introduction of this elementary use of tools into schools for younger boys, now known as manual training schools. This was extensively carried on by Prof. C. M. Woodward of St. Louis. The distinctive feature of the manual training, as then introduced, was not to teach trades but to avoid construction for the sake of instruction; but as time goes on all manual training schools are more and more inclined to combine instruction with construction.

Professor Lanza said that he remembered well the establishment by Professor Runkle of the School of Mechanic Arts, which was what is now called a school of manual training. In this school handwork was taught by the laboratory method for purposes of instruction, and not through construction, as had been previously done in this country.

This fundamental idea, which forms the basis of manual training, was the subject of a great deal of discussion, at the time, at the meetings of the Society of Arts, Professor Runkle claiming that when the object of a school was construction any given portion of the work would naturally be assigned to the boy who could do the work best, whereas he was the very one who needed it the least.

President McNair said that the report is of vital interest to every member, and that if it does nothing else it will set each one to considering what should be the relation of his institution to this important matter of industrial education. He testified to his own deep interest in it, and hoped the discussion would follow more closely along the lines of the report.

Mr. Kent congratulated the Committee on their report, and believed it to be one of the most important that has come before the public in many years; he was glad, therefore, that the Committee is to be continued. He expressed the hope that next year the Committee would take into special consideration a subject which they have discussed in a small way this time; that is, the subject of the mono-technic school, with which scarcely a beginning has been made in this country. He thought that the report next year should contain such information as can be gathered concerning the history and work and development of those schools that are on record in this country; and he also asked to have something done about recommending the establishment of such schools in some of the universities. Mr. Rothwell had made some statements to the effect that it is better to spend the money devoted to educational purposes on a large number than on a few. As regards the community as a whole, the speaker did not know whether this would be true or not. He thought it would be better to spend $5,000 to educate one man as a first-class engineer than to fritter away that $5,000 in a hundred parts of $50 each. The whole system in England along these lines has been a failure; and with us it is true that the night school is not always valuable, although the Cooper Union night school has been a magnificent success. It has a large endowment, paying good salaries to its professors and keeping them for years; it has a good building and a location in a densely populated city. In regard to the ends in view, in industrial education, whether to educate a few people to be foremen and superintendents of works or to educate the masses, both of these subjects must be considered by the Committee and by everyone interested in industrial education. One is to improve the condition of the great majority of boys who are to become artisans and to provide the works with more intelligent workmen. The second relates to the condition of the industry as a whole and of the nation in competition with other nations of the world. I think the supremacy of the United States in the textile industry will not be gained by giving a slight degree of manual instruction to the great mass of textile operators, but will be secured through the endowment of strictly professional textile schools, which will be patronized by the sons of owners, who can spend four years and pay high fees. There is a lack of higher training in textile industries especially in this country. There is also a lack in industrial art schools, particularly applied to furniture, house decoration, pottery and the like. Professor C. M. Woodward has made use of the expression "putting the whole boy to school." Now let a broader view be taken when these industrial schools are established. Train the head and the heart and the conscience as well as the hand. There is danger that only the manual part of the man may be developed; but there is an education needed for the artisans and workmen of this country which is fully as important as that which will enable them to earn more dollars per week. Each workman should be made to understand that his fellow-workman has just as good a right to a day's work as he has, and that he has no right to stone or shoot another for taking the job he has left vacant.

Col. E. D. Meier said that the subject was one which necessarily interested him as it must interest every engineer and employer of skilled labor. He desired at the outset to compliment the Committee on the very comprehensive report and the thorough manner in which so many points bearing on the main subject have been worked out in every detail. He added that the very perfection of the report made him hesitate to speak on it without having had the opportunity of studying it thoroughly, and that he must be excused, therefore, if he approached the subject from only one or two points, it being realized that it is possible only to skim along the surface; that the report deserved to be carefully studied before anyone could attempt a fair criticism.

He remarked that one of the speakers has very aptly stated that for most men it is natural to interpret as a liberal education the education which he has himself received, but that he must differ from the gentlemen in regard to that, since a liberal education is generally understood to mean an education in which the study of the classics of certain dead languages, representing an older civilization, has a prominent part. The speaker stated that when he was young, for instance, a liberal education was considered possible only with a large amount of cramming in Latin, that he had himself spent nine years in translating what was presented to him as very good Latin into what he knew to have been very poor English, and that when he rebelled against a mental pabulum which seemed to him neither pleasant to the taste nor in any sense nourishing, he was sagely advised that Latin was very useful, if not absolutely necessary, to enable him to understand his own and to learn foreign languages. He had since found this to be an almost baseless superstition, and that there was only as much truth in it as underlies superstitions generally.

It is of vastly greater importance for a boy to know something about the facts of nature and the laws governing every action, than to memorize a number of Latin prepositions which govern the ablative and forget them without half trying. The very point of Dr. Mendenhall, that the better part of the man should be educated, is met by an education based on the natural sciences. It was natural enough a century or two ago, when the sciences were all in their infancy, to place the mere learning of languages, which had preserved a former great civilization, in the foreground. There was then nothing else to teach, and the mental appetite had to be fed by the best food available, but that trouble does not exist now. There is now before one in his youth, and still confronting him at three score years, more knowledge to acquire than can be compassed with all his appetite and all his zeal.

The great difficulty with the engineering college is the very limited time in which the student must absorb the mere elementary facts and laws of the many sciences which govern the work of the engineer. Very much of this elementary work ought to be done in the preparatory schools, and it is really pitiful to think of the time spent in drilling boys in methods of spelling which are known to be absurd, and in studying Latin authors whose works can be read in translations better than any boy ever makes, which time might be much better spent in teaching him elementary mathematics, biology, physics, chemistry, etc., and the various elements of manual training.

The new education should begin at the beginning. The speaker said that he would not enter into the discussion as to the priority of the introduction of manual training into the schools, although he saw a potent promise in the fact that at least as many cities claim the honor, as it is reported once claimed to be the birth-place of Homer. Manual training, or rather training of the hand and the eye both, should be commenced in the kindergarten and continued through the public schools. Incidentally one of the speakers has just referred to the necessity of teaching housekeeping and cooking to girls as part of such manual training. There is reason in this, for it is patent to all who have traveled in Europe that this very knowledge among the women of the working classes conduces to the general content with which much lower wages are accepted. With better cooking at home many saloons would go out of business.

The speaker thoroughly agreed with Mr. Kent that if only one thing can be had it is better to educate a few very thoroughly than to give the masses a mere smattering, but that does not argue that it would not be of great value to teach a certain amount of the knowledge on which an engineering education is based, in the grammar course of the public schools There is nothing a boy likes so well as to be shown. how to make things. It is generally known that a boy would rather take a soap box and nail an axle with a pair of wheels under it than to have a nicely painted wagon bought in the shop.

There is no reason why the manual training begun in the kindergarten should be dropped in the grammar school. The Manual Training School of St. Louis, which has been referred to, is of the grade of a high school, and there is no reason why in a large city there should not be several different kinds of high schools.

The division of labor which the highly complex modern civilization demands brings with it the necessity of differentiating earlier and giving each child a chance to learn that for which it has the most taste and talent. When fewer square pegs are put in round holes many social questions which now stalk around and threaten our civilization will die of inanition. The speaker remarked that he once met a learned professor, who knew twenty-two languages, that this professor exhibited to him his ability to translate either ancient or modern Coptic into good

English off-hand ; that he was a very learned man, and could talk and write in twenty-two languages, but that when he tried to give facts in any one language he showed that his positive knowledge was very limited.

Engineers should live right up to their conviction that an engineering education properly carried out is as liberal, as humanizing, and as noble as any that can be given ; that it depends not so much on what one studies as on how one studies ; and that there is to-day nothing else so much needed by every man and woman in the world as a clear understanding of many principles of engineering. Every day men and women come into contact with machinery and depend more on it ; there are many dangers which are dangers only to the uninitiated and such knowledge even if very elementary, provided it be correct, is as necessary to the average civilized man of to-day as the art of fence was a century or more ago.

In comparing the various schools, including the correspondence schools, as Mr. Higgins has done, with the trade schools of Europe, a radical difference must be pointed out as is in fact done by the report. In the social life of Europe a horizontal stratification has been going on so long that the methods adapted to their conditions cannot be applied to the schools of this country. A system is needed here in which there should be free vertical motion, so that the boy of real ability may rise rapidly from the bottom to the top, by his own energy and force, as the bubbles of steam rise from the furnace sheet to the steam drum.

Many improvements in engineering which have originated in Europe were brought to fruition in America, because of this very difference in social statics. Papin was mobbed by the Weser flat-boatmen, Fulton exalted by his hopeful countrymen; Bessemer invented the steel converter, Hawley quadrupled its capacity and efficiency. Italy, France, and Germany developed the dynamo; America makes it a potent force, propelling thousands of cars and illuminating a million homes.

Notice the difference in method by which a new engine or machine is built in Europe and in America. In Europe the engineer makes a design, signs his name to it and it goes on its way. The pattern maker may see great difficulties in pattern and core boxes, but he dares not say a word, but makes it as the engineer has drawn it. The moulder dares not criticise, but goes to any expense in order to carry out the design exactly as it comes to him, and so on through the whole establishment. There may be many hours of hand work, chipping and filing, which could have been made machine work by a slight change in design, but the horizontal stratification does not permit of intelligent co-operation between the lower and upper strata.

How differently the work is done here; the designer freely goes into the pattern shop and takes suggestions from the pattern maker, consults the foundryman in regard to the drawing of the patterns, shrinkage strains, etc., and so on through the entire machine shop. By the time the machine is finished it is very different from the original design, but is generally much better. The American engineer knows that he has only been utilizing different kinds of special knowledge which it his duty to utilize and which each one of these men has obtained by thoughtful and loyal work, striving to do the best in his own particular line.

The speaker said that he saw in this at least one great reason why American machinery, and especially American machine tools, are so much better adapted to the work to be done than European machinery. The imitation which English and Continental manufacturers practice is the sincerest flattery for American designers and builders.

The speaker urged, therefore, the importance of so shaping our system of training that the various branches of engineering activity may keep in close touch with each other; that the skillful workman, the intelligent and faithful foreman, the well-trained and well-balanced superintendent are just as necessary as the brilliant engineer who commands the industrial army, and that the higher his education and training goes the more necessary it is that those who are carrying out his designs are trained in the same spirit, although naturally on somewhat different lines.

Mr. F. A. Halsey referred to the wide scope of the report as an indication of the vastness of the field of industrial education and expressed the opinion that the magnitude of the work to be done leads to a tendency toward discussion rather than concrete action. He lamented the fact that there had been so little said of a nature to induce any one to put up the money for the establishment of a monotechnic school. He considered it a fortunate circumstance that one trade is now loudly calling for the establishment of a school in its own interest because this fact gives this Society an opportunity to ally itself with a movement which has already been started by men in commercial life, who are thus in a position to understand the needs of their calling, and who have given expression to their views in the following series of resolutions, which were passed at the April meeting of the Pittsburg Foundrymen's Association:

Resolved, That the foundry industry has arrived at a point where there is a demand for managers properly trained in the principles of scientific and commercial founding.

Resolved, That a representative body such as the American Foundrymen's Association be requested to draw the attention of the institutions of learning in the country to this fact, and urge them to take the necessary steps to supply the demand.

Resolved, That the Pittsburg Foundrymen's Association authorize the appointment of a committee of five, acting in conjunction with committees that may be appointed by other foundrymen's associations to memorialize the American Foundrymen's Association in accordance with the above resolutions.

This movement for a school of founding has received the endorsement of men. who, on the one hand, have come up from the ranks, and who thus represent the strictly practical element of the business, and of those who, on the other hand, possess the highest scientific training. The speaker considered that this Society could take no better action than to endorse these resolutions.

Professor Allen suggested to Professor Johnson that it might be worth while to look up the matter of university extension. He thought it was not altogether out of the line of activity of the University of Wisconsin, and it occurred to him that there might be a chance for development in the direction of university extension, which has been used more in connection with ordinary college work than for engineering courses.

Professor Johnson thought that much of the discussion about manual training arose from an erroneous conception of what a manual training school is. The whole matter will, however, be laid before the Committee for their reconsideration, and such action as it may take will appear in the revised published report. The speaker declared himself as still unconvinced, however, that the statements made in the report were not entirely justified. Manual training is not simply shop instruction. For the manual training school, as such, he thought that Professor C. M. Woodward was entitled to all that was claimed. He had been fifteen years defending it before the world, and the speaker had been intimately associated with him as a fellow professor in Washington University.

As to the future work of this Committee, he thought it would lie rather in the accumulation of facts concerning particular schools, and in making the report concrete in the direction of special kinds of mechanic arts and trade schools. For completeness, it ought of course to include the whole field, but the emphasis will be especially on the particular kinds of schools available for industrial education, with as much concreteness as possible for the purpose of aiding generously inclined capitalists to work for the good of the cause. The speaker desired to have some expression of opinion as to how elaborate such a report should be made. It is quite possible that it ought to be made large enough to be a little booklet in itself. And it could be sold, of course, so that the Association might authorize the gathering of such facts as would make up a book that should be published and put on the market. He did not think the Society would endorse by resolution any report that the Committee might make, and that their approval should be limited to the publication of the Committee's report.

SECONDARY TECHNICAL EDUCATION IN MECHANICAL AND ELECTRICAL LINES.*

BY ARTHUR L. WILLISTON,

Director of the Department of Science and Technology, Pratt Institute.

This Society is already mindful of the necessity for further provision and increased opportunity for Secondary Technical Education in this country as a condition of its industrial well-being, and it is not the purpose of the writer to dwell on this side of the question, but, rather, it is to try to point out one way in which this demand may be met, at least along certain lines.

As long ago as 1878, in a report to the State of New Jersey, Dr. R. H. Thurston called attention to this need, stating that for each technical university or college there ought to be about thirty technical schools of high school grade; and Professor J. B. Johnson two years ago, in his Presidential address at the Boston meeting of this Society, brought the question of this necessity before us in so forceful a manner as to leave little to add.

One point only in this connection would I emphasize, and that is the fact that in all the mechanical industries conditions are changing so rapidly and have changed so much even in the last two years, since Professor Johnson presented his paper, as to very greatly increase the need of some technical training for all those who are to enter manufacturing pursuits. For we are at present in the midst of one of those industrial upheavals similar to the one thirty or forty years ago, when the general application of mechanical power to all the problems of production and transportation gave impetus to all kinds of manufacturing enterprises and in a few years transformed the few short lines of steam railroads connecting some of our older cities into an endless network covering an entire continent.

---

* This paper was read as a part of the discussion of the Report of the Committee on American Industrial Education.

This application of mechanical power to all these new problems a generation ago called for a class of men who were able to forge ahead into new and untried fields—men who were trained in the mysteries of science and who were able to make all her forces best serve their purposes. The demand was for trained engineers of the highest type.

We all know how well this demand has been met and how one State after another took advantage of the provisions of the Morrill Land Grant Act and established colleges or universities which should include courses in applied science; and how independent schools of engineering were formed and how existing colleges were forced to include similar courses in their curricula, until to-day there are over one hundred institutions in the United States conferring degrees in engineering. From the start the aim was to make these courses as broad and as thorough as possible in order that the graduates they sent out into the world might be fitted, after they had supplemented their college training with practical experience, to handle the largest and most difficult enterprises. Thus this demand for engineers was met by generously providing schools in such number and of such character as to give young men an abundant opportunity to prepare themselves for the work that needed to be done.

To-day another revolution in our industrial affairs has been going on quietly and unobserved, which has given us new problems to solve. Automatic machinery is everywhere taking the place of hand-operated machines and special tools which turn out a given piece of work by the thousands or tens of thousands are taking the place of the older tools; and the skill that was formerly exercised in producing an accurate piece of work on the lathe is now used in constructing the special tool which will produce it with still greater accuracy. And there is now a demand for another class of specially trained men to meet these new conditions.

At first thought the change which is creating this new demand seems to be of far less importance than the earlier one, for it simply means that machinery has become more complicated and, like everything else at the close of this nineteenth century, has become highly specialized—a special machine for each special piece of work. But when we carefully consider it, we see that the second change is the greater. The change from the first hand-printing-press to the power-driven press was not so great as the change from the early power-press to the intricate mechanism by which a modern newspaper is printed. The first change animated iron and steel with physical force, and the second has endowed them with intelligence. This is but one illustration, but it is no more remarkable than hundreds of others. Take, for example, a machine which receives rough castings fed into a hopper at one end, and, without human intervention of any kind, turns out at the other end hand-wheels for a sewing-machine, turned and polished on the rim, with a groove for the belt, faced on both sides of the hubs, and even drilled and tapped for the set-screws which are to hold them in place. Or take the screw machine, which goes on making perfect screws so long as the coil of wire from which it is fed lasts, and works as well when unattended as if receiving constant care.

In almost every industry we see the introduction of these improvements caused by competition and the effort for better production at less cost; for the purpose of the more intricate tools is to secure more rapid and, at the same time, more accurate results. As the quality of the result now depends more on the tool than on the workman, it is possible to employ cheaper and less skilled mechanics to do the work, and we notice everywhere this effort to utilize cheaper labor for all kinds of production.

It may appear, therefore, that the result of the modern tendency is working against the interests and the development of the great body of wage-earners, for automatic machinery seems to be continually responsible for the replacing of skilled workmen by less skilled and for the substituting of the machine tender for the real mechanic. But if we look closer, we shall see that this is not exactly what is going on. Machine tenders are not taken from the ranks of the mechanics, but from the ranks of the laborers; and the real fact is that laborers are being educated to be machine tenders and the skilled and intelligent mechanics are being educated to the positions of tool builders and tool designers wherever it is possible; so that each class is being advanced and made more productive and each shares in the benefit of the larger production. Thus the present progress and development are not against the interests of skilled labor, but for them; and there is growing a great demand for skilled and more intelligent workers whose positions shall be midway between the engineer,—who stands at the top and directs—and the mechanic of the old type,—who did the actual work.

Both in the draughting-room and shops of all our mechanical and electrical industries is this demand becoming more urgent for men who have had sufficient training in applied science to enable them to grasp and understand the plans of the engineer above them and who have sufficient knowledge of practical details to direct the carrying of them into execution. And this demand is all the more urgent because for every engineer and master of construction a dozen men of this other type are needed to carry out his plans.

No better proof of this statement could be had than is offered by the very general eagerness for technical training among those employed in the various mechanical lines, in order that they may rise to fill such positions. The fact that there are at present in a single one of our correspondence schools over 180,000 students—by far the great majority of whom are taken from just this class of young men—who are paying out their hard-earned money in the hope that they will get some technical education that will help them to get ahead, shows most clearly how widespread is this desire for sufficient theoretical knowledge to enable workmen to understand the principles that underlie the machinery and electrical apparatus with which he must deal. Other facts could be cited, but they all show that to-day the mechanic almost universally believes some technical training to be necessary for his success, and also that he is, without question, right in his belief. Indeed it is remarkable to see how rapidly the appreciation of the value of technical training has grown among all classes of workmen.

Granting, then, the existence of this growing demand for a combined technical and practical training for those who are to fill the positions between the engineer and the mechanic, which have been brought about by the recent advances in methods of manufacture, the question at once arises, "How shall this demand be met and where can young men find the training that is needed to develop them?"

I will now, under the various headings, briefly point out some of the limitations of existing methods; and under the head of Secondary Technical Education, will try to describe the type of school which I believe will best meet the present need.

THE OLD SYSTEM OF APPRENTICESHIP.

A few years ago the *American Machinist* sent out a large number of inquiries to the leading manufacturers to find out, if possible, how far the system of apprenticeship in America was still employed and to what extent the trade-unions under foreign control influenced the conditions or were opposed to having American boys learn trades. In the course of this investigation two hundred letters were addressed to leading firms asking for information regarding their policy and for their views on this important question. Answers were received from 116 establishments, of which 85, or 73 per cent. employed apprentices; and 79, or 92 per cent. of those who so employed them expressed more or less satisfaction with the results of the system. It was plainly shown from the answers, that in those trades which had to do with machine construction the apprenticeship system was still largely employed and that, so far as could be discovered, the trade-unions exerted no appreciable influence. But there was nothing in the investigation to show that in those establishments where apprentices were taken they formed as large a percentage of the total number of men employed as formerly, nor was there any evidence to prove that those who were employed received anything like the equivalent of the instruction which was given when the apprentice could come into close personal relation with his master, instead of being a part of a large corporation.

The absence of this information makes the figures misleading. They show that in one way or another the great majority of machine tool builders employ boys whom they call apprentices and for whom they probably do the best that they can under modern conditions. But they do not prove the common belief to be groundless—that the system of apprenticeship is becoming less and less able to provide for the future needs of American industry. The investigation showed that the prejudice of the trade-unions is exerting little influence, but it did not prove the absence of more powerful causes at work, to make the system less effective. Among the most important of these are the following:

First. The scale on which manufacturing is to-day carried on makes impossible the personal relation between master and apprentice which gave the old system so much of its strength.

Second. The rapidity with which changes in method of manufacture are now being made, due to new inventions and the introduction of labor-saving devices, makes it less desirable for a boy to spend three or four years learning a trade which may be greatly altered before he has mastered the old ways. Formerly when changes were slow and industries were conducted by mechanics who had themselves acquired their methods from their predecessors, the slow method of learning by imitation of others could easily keep pace with the progress. To-day changes follow one another in such rapid succession that the more speedy method of learning through the process of scientific reasoning is necessary.

Third. The introduction of automatic machinery and modern methods have so changed the conditions that it is cheaper for each man to do one thing. The long apprenticeship is not necessary for this and cheap labor can be quickly trained to do the work. This offers a great temptation to boys of little ambition to leave their apprenticeship and to learn to operate one machine at slightly better pay.

Fourth. The application of science to nearly all classes of industry and the placing of them under scientific direction make it necessary for the young man to understand the scientific principles and their application to his particular calling as well as to possess mechanical skill at his trade, else his advancement must be limited. The manual methods could be learned in the old way in a commercial shop, but the scientific principles must be learned elsewhere. In school or college only can the young man get this combination of scientific and practical training which is to-day essential to his success.

Each of the above reasons applies with greatest force to those industries which have been most affected by recent improvements and had the investigation of the *American Machinist* been conducted among the class of manufacturers who build sewing-machines, bicycles, and the like, instead of among engine, locomotive and machine-tool builders, where a large part of the work is still individual, it is possible they would have found a large number of boys employed as machine tenders ; but it is unlikely that they would have found any true system of apprenticeship.

Thus, as scientific methods find their way more and more into all our industries under modern competition, the old system of apprenticeship in America, which has done so much to train men who have become leaders in mechanical lines, will be more and more unable to meet the demand, and something else will have to take its place.

THE MANUAL TRAINING HIGH SCHOOL.

We find here a movement which has been growing rapidly and which has recently been exerting a marked influence on the whole school system in the United States, but its help in the solution of our present problem is only indirect. The aim of the manual training school is toward general education not technical. It embodies, it is true, some things that are common to the technical school, but they are given from a different point of view and manual training would lose much of its strength and significance if the technical features were to be over-estimated.

In the manual training school, shopwork enters only as one of several means of training all the faculties necessary for the full development of the child. And it enters because of the belief that through it mental activity and growth on the part of the pupil can best be reached; and because of the opportunity which it offers for quickening the senses by close observation, developing the reason and judgment by the constant use of method, strengthening the will by each new difficulty overcome, and cultivating habits of care and perseverance, neatness and accuracy. It enters because of the training which it offers in *doing* as well as thinking—for all thought which does not result in action is in a sense incomplete. The manual training school is therefore not especially intended for any one class of pupils or for those who will follow any special calling; but it is rather a general training for any walk in life.

In some instances the demand for some form of elementary technical training has led the manual training schools to try to meet the demand. But it is the writer's opinion that the necessary sacrifice in other directions is too great: and that they can be of the greatest service to the community by standing squarely on the ground that manual training in one form or another is a necessary part of all education, and by using their influence toward its adoption into all parts of the school system, from the lowest to the highest.

The graduates of the manual training school are of course better prepared to enter industrial pursuits and rapidly acquire the training that they need than are the graduates of other schools (although their advantage is not nearly as great as would be the case if manual training entered all the schools from the lowest grades); but we cannot regard the manual training school as a technical training.

THE DAY TRADE-SCHOOL.

The trade-school pure and simple has, for one reason or another, never greatly prospered in America. This statement refers to those schools where the teaching of the trade, the manual operations and skill necessary for the particular industry, and the utilitarian and commercial point of view have been kept in the foreground; while the development of the individual and his mental growth and progress have received but secondary consideration. The idea is fundamentally wrong. No bright, ambitious American boy is going to enter a calling where the possibility of advancement is closed by anything but the limit of his own natural ability; and the idea of a school where he is not encouraged to think too much for fear he may not want to stay working at the trade for long after he leaves the school, but will be ambitious for something higher, is very naturally distasteful to him.

Even though the importance of the individual development is fully realized, but is sought through trade instruction, the results will be hardly more satisfactory, because a course of manual training alone without any so-called intellectual training is as one-sided and irrational as a course which seeks to develop any other single set of faculties.

There is another class of schools which are really secondary technical schools, although they are sometimes, in the opinion of the writer, incorrectly called trade-schools, which endeavor to embody with the instruction in the practical details of the trade or industry, a thorough instruction in the fundamental principles and sciences which underly it. Such schools as the Lowell Textile School, the two-year course in Ceramics at the Ohio State University, or the Half-Time School proposed by Professor M. P. Higgins where half of each day would be devoted to general and technical instruction with special reference to machine construction, are schools of this type; but these will be discussed later.

EVENING TECHNICAL AND EVENING TRADE-SCHOOLS.

Of course little can be expected from this class of schools as compared with day schools. The hours are short—only about six hours per week—and oftentimes they last but six months in the year, during the fall and winter months as a rule. With these hours, it would take about eight years of evening work to be the equivalent of one year of regular day work. But more than this, the evening work comes at a time when the student's best energies are spent by the day's work, so that the time which is devoted to the evening classes is apt to be most inefficient. There are, however, some exceptions to this rule.

A lawyer who has spent his day in court, can give his best energies to a game of chess in the evening, because he is using a different set of faculties; and it may be that the chess is the best possible way of preparing himself for his next day's work. If evening classes can be conducted under these favorable circumstances, we may expect most gratifying results; and in planning evening work it should be the constant endeavor to appeal to those faculties which have not been used during the day.

In some of the evening classes which come under the direction of the writer at the Pratt Institute, we are able to do this. For instance, in our evening classes in chemistry, where most of the young men come from chemical works or laboratories where they are not entrusted with much responsibility or brain work during the day, we find the students able to take hold of theoretical chemistry in the evening with enthusiasm and their progress is excellent because their minds are fresh for the kind of work that is given them. If they were differently occupied during the day, this might not be the case.

Or take our evening class in machine work, where all members of the class are engaged during the day in shops doing, as a rule, comparatively heavy work, but not being required to use their minds much. Here we are able to hold a high degree of interest and develop the men to a surprising degree by keeping their minds constantly employed with frequent short talks on machine shop mathematics and its applications and by continually giving the men what are for them knotty problems on milling machine, grinding machine, lathe, or planer. They puzzle over these things at night and they continue to puzzle over them the next day. Thus by giving these men who work with their hands all day intellectual training in the evening which exactly fits their daily work, it is possible to make the evening work count for as much as would the same amount of time during the day under what would seem to be more favorable conditions.

Another illustration which I think will be of interest to the Society, is the evening class in plumbing, which is composed entirely of plumbers' helpers—not the best class of young men, one would think, for an educational experiment. These boys have been doing all the hard work during the day, while the journeymen for whom they are helpers have been doing the nicer parts. They have been denied the privilege of doing anything interesting. Their hours are long and they come to the evening classes often directly from work, with only a cold dinner that they have carried since morning; yet their enthusiasm is undaunted and their regularity in attendance is excellent. Their instruction at the Pratt Institute is quite thorough on the heoretical side of the trade and their work in the shop is almost entirely of a kind that requires much nicety and skill, but little real work: so that in two directions faculties that they have little chance to exercise during the day, are brought into play.

I asked the instructor of this class a short time ago to look up the record of some one of the recent classes and let me know what each one was now doing. For convenience he selected the first class in his present roll-book, which happened to be the class of 1895–96.

Some of these had previously been with us for one year—for it is a two-year course—and therefore were completing their second year, leaving us four years ago; some, the majority, were taking their first year, and finished their course only three years ago.

There were 49 members of this class:

9 we were unable to locate.
1 is in Manila.
1 perished on the Maine.
22 are regular journeymen.
7 are master plumbers.
5 are salesmen in plumbing supply houses.
1 is superintendent for a large plumbing firm.
1 is a draughtsman on plumbing plans.
1 is sanitary engineer for a trade paper.
1 is a bicycle policeman.

Only one of those heard from has left the trade. All the rest have stepped up at least one notch in the social scale in this short time and nearly half have stepped up two or three notches. In their evening classes they learned to think in connection with their work, and they have kept on thinking ever since in competition with men who are not in the habit of putting over-much thought into what they do. The result is that they have begun to get ahead, and they will continue to get farther ahead.

I have given the above illustrations to show that in certain cases and under the right conditions the evening trade school may be of much service; but they also show that it alone is unable to supply the want for thorough and systematic technical instruction.

THE CORRESPONDENCE SCHOOL.

The Society is familiar with the work of the correspondence schools and I have already referred to the remarkable growth and enormous enrollment of these schools. The first school of this kind for technical instruction was organized in 1891, and it now numbers over 180,000 students, as has been said; and there are five other such schools entirely or largely devoted to technical instruction, while several others, and at least one State University, offer these courses.

Such a growth indicates a demand for technical education which should be met in the best possible manner. How much of the demand has been created by the correspondence schools themselves is not important in the present connection: the fact that such numbers have been found who are willing to devote time and money to the acquisition of knowledge raises the question whether this field can best be filled by the present method or by some other. Ambitious workmen have awakened to the importance of understanding the principles and practice of their trade or business in all its branches. They feel a need of systematic study under wise direction, which correspondence instruction offers in such form that they can take advantage of it. The press of competition has made knowledge necessary, and the advertising work done by the correspondence schools has helped to awaken in many the desire for it and to point out a means to its attainment; and of such men the correspondence school enrollment is largely made up.

There are of course many disadvantages under which the correspondence method labors. Students lack the inspiration which comes from personal association with teachers. The laboratory method is impossible. The student must wait for days before his questions are answered, and the instructor must often fail to understand where the difficulty lies. This is not in criticism of existing schools, but a statement of inherent difficulties.

On the other hand, the student may begin his work at any time and proceed as slowly or as rapidly as his ability will allow; real individual instruction is possible and there is plenty of time for a large number of practical problems applied to the particular field of work in which the student is interested. But probably the greatest advantage of the correspondence method to the majority of the students, is the fact that the instruction can come to them and need not interrupt any regular occupation. Leaving this out of account, however, there is no question but that the disadvantages far outweigh the advantages. But to those who, by situation, are deprived of the other opportunities or to whom any regular instruction would be impossible because of interruptions to regular work, the correspondence schools are a great help and are giving them much assistance in their effort for self-advancement.

It would be wrong to suppose, however, that the correspondence school could ever take the place of the regular technical school nor do the correspondence schools claim this. The correspondence school has rather increased the demand for the regular school by increasing the desire for technical education.

The Secondary Technical School.

The idea of the secondary technical school which gives thorough instruction in mathematics, science, and all the principles underlying the technology of a given industry or group of industries, is comparatively new in the United States, although in Germany for more than forty years these schools have existed and have in fact been the mainstay of her system of technical education. Many of us have regarded these German schools as trade schools, because they were of lower grade than our technical colleges and universities, when, as a matter of fact, as Professor Johnson pointed out two years ago, the practical instruction in these schools was no more important a feature than the instruction in applied science; and when, in reality, they were more like our polytechnic schools, only of secondary grade.

It is this class of schools that I have referred to as secondary technical schools and it is this class of schools which I wish to speak of now—schools which bear exactly the same relation to our polytechnics that the best high schools and academics do to the classical colleges, leaving out the college preparatory idea.

I have referred to the Lowell Textile School and the school of Ceramics in Ohio as examples, and there ought to be in this country to-day many more such schools, not only in the textile industries and the clay industries, but also in other similar lines, such as the metallurgy of iron and steel and the various lines of chemical manufacture. But more than all else, there should be in every State in the Union for every center of population, technical schools with special reference to the machine trade, because the machine trade, it seems to me, is fundamental to and lies at the base of all our manufacturing industries and is most closely allied to all our industrial progress and welfare. The rapid introduction of automatic machinery into all lines of manufacture — whether bricks or paper bags, watches, or machine-tools are the output— has vastly broadened the field for the trained mechanician; and the increased scale on which material in all its operations is handled, has increased equally the importance of having mechanically trained men for foremen, superintendents, organizers, managers, etc., in all lines.

The graduates of our engineering colleges have had a training to admirably fit them for positions such as these after they have the necessary experience to familiarize them with all the practical details of the particular business and have learned how to handle the men who would be under them. Each year a few of the engineering graduates do leave behind the larger problems for which their training was especially designed, to enter manufacturing industries and supply a portion of this demand. But as a rule they are unwilling to commence as low down on the ladder as is necessary and they can usually find more attractive openings in the strictly engineering work. They therefore make but a small impression on the demand. And for those who wish to prepare themselves especially for industrial pursuits, the engineering course, with its high requirements for admission and its long mathematical training before the degree is reached, with the greatest part of the real technical work in the fourth year, offers a training which is for the most part beyond their reach or one which is most uneconomical for their purpose, if they are not wholly debarred.

* * * *

In the foregoing I hope that I have made it clear that in this country, which is fast becoming a manufacturing country, we need a mechanical training not for the few, but for the many; for the sons of artisans and wage-earners; for the great body of our working people; so that there will be the possibility of advancement for all, and such that the capable and ambitious boys of the type that, under the old system of apprenticeship, became the mechanical leaders in the development of our industries, will not be lost to the trade and will not feel that there is no chance of advancement if they enter an industry at the bottom.

I have also tried to show briefly that neither the old system of apprenticeship nor our manual training schools, nor trade schools, evening schools, correspondence schools, nor engineering colleges—neither one nor all—are altogether adequate for the purpose that I have named.

The question then asked is, what kind of schools should we have; how long its course of study; what its requirements for admission and what its requirements for graduation; what subjects should be included in its curriculum and what methods should be employed? Briefly, I will try to give my own opinion on some of these points, but many of the final details will be influenced by the local conditions.

The course might well be a four-year course corresponding to the four years of our high school,—and this would be none too long. But the first two years of the course would be more or less general and would differ not so much from the first two years of our existing high schools,—just as the first two years of the engineering course differ not so very much from the first two years of an academic college course. For this reason, with our high schools already developed, the secondary technical schools for the present at least and until they have received general public recognition and public support, would do well to confine their work to what would correspond to the last two years of the high school course and let the existing high schools provide for the earlier years. Under existing conditions there is a double advantage of doing this: first, it enables the technical school with a given equipment to give its training to twice the number of individuals and in this way to do nearly twice the service to the community; and, second, it offers those who left school at the end of the grammar school course and entered industrial pursuits but have since found the necessity of technical training, better opportunity to get what they need in a short space of time. If the technical schools were as common and as generally recognized as the high schools are to-day, this necessity of providing for those who did not know the value of technical training would not exist, as common experience would have demonstrated its necessity.

For the present, then, the course should be two years and the requirements for admission be high enough to cover the first two years of the high school or at least to insure an equivalent in maturity, character and earnestness of purpose in those who have left school earlier and gone to work. A thorough examination in both arithmetic and English may be made to test this as well as a longer list of subjects.

The requirements for graduation should be as high as it is possible, with the best facilities and the best instruction, to make them; but at least they should be sufficiently high so that the best students could be admitted to the majority of the engineering colleges on graduation in case they should desire it. Of course they would be conditioned in languages, but they should be able to get enough advanced credit for shopwork and drawing to be able to make these deficiencies up during the first year of their college work.

There is little opportunity for difference of opinion as to what should enter the course of study for the first year. Mathematics and physics are both fundamental to all mechanical problems and should therefore enter prominently. Design and construction should also be emphasized. Each day, therefore, there should, be mathematics, physics, physical laboratory, shopwork, and mechanical drawing. If the day is divided into eight periods, this gives one period for each of the two recitations in mathematics and physics and two periods each for laboratory drawing, and shopwork. Add to this two hours and a half for evening study, and you have a day under which any healthy boy will thrive. Such a large part of his time is taken up by work requiring physical activity, that he finds his task a wholesome one.

The mathematics of the first year should include algebra, plane geometry, and elementary trigonometry—but not taught from the ordinary text-books The mathematics will give the best mental training and the broadest, if it is closely allied to the other work so that it may be more thoroughly understood in its meaning and its application. And as the young men are to enter the field of construction, all their school training will have the greatest educational value if it is closely allied in purpose and spirit to their life-work, so that the process of thought and education may continue without interruption after they leave school. Therefore, the mathematics should be made practical and constructive. The student should be made, not only in geometry but in all other branches, to construct his own proofs and to build up step by step, under close and continual guidance, his own methods of reasoning.

The physics, too, should be taught with special reference to the work that is to follow. Mechanics and certain portions of heat and electricity should be dwelt on; the remainder may be passed over more rapidly. The laboratory process should largely be relied on and an effort should be made so to equip the laboratory with simple, yet effective apparatus, that every principle of importance—either because it is fundamental to an understanding of what is to follow, or because of its application in practical work—may be studied through the medium of at least one laboratory exercise. The idea is to gain the desired end by constructive steps based upon doing, rather than to attempt to reach it through the application of abstract logic; and many portions of physics which, approached by any other method, would present mathematical difficulties beyond the powers of secondary school students, may thus be studied with considerable success. The experiments should have, wherever possible, a practical as well as a disciplinary value and the prime requisites for the apparatus designed for the use of technical students of as mature age as those who will satisfy our entrance requirements are: that the apparatus shall not be trivial, but shall be of a character to awaken interest; that it shall be capable of definite ends and useful purposes; and that it shall give quantitative results that will compare with those used in professional work.

The drawing and shopwork shall be as practical as it is possible to make them, and in planning the work and the equipment it should be remembered that much may be left to the imagination of the college student, but for the student of our technical school no equipment is too good and no thought and care in methods of presenting work to him is too great. In both drawing-room and shop, pains should be taken to make use, wherever possible, of what has just been learned in the classes.

In the time that is available for shopwork, it is possible to give a pretty thorough course in pattern-making, foundry-work, and forging in the first year. The drawing may be made to include geometric drawing or orthographic projection and shop detail and assembly drawings made from student sketches.

The work of the second year may not be so clearly defined, as there is more room for individual judgment to vary the course of study; but the fundamental idea marked out for the first year will prevail in the second. I would suggest, however, the following: Mathematics every day; a recitation in mechanism, mechanics, strength of materials, and steam, to take the place of the first year physics; and the balance of the time divided between machine design, machine construction in the shop, and mechanical laboratory which now takes the place of the physical laboratory.

In mathematics, more advanced algebra, solid geometry, and some more advanced trigonometry, with the elements of analytical geometry, may be covered.

In the machine shop ten hours a week may be had throughout the year, which gives a pretty thorough and complete course and enables a good deal to be done in the way of tool-making, cutter and reamer grinding, etc., in addition to a large amount of machine construction; and the course in machine design may include design of machine details, and after the strength of materials has been taken up in laboratory and class-room, design involving strength calculations.

In the mechanical laboratory and the class-room work that accompanies it there is more room for variation than in any other point in the course. It may, however, include power measurement with indicator and brake; transmission of power with belt, rope, gears, etc.; measurement of friction losses; efficiency calculations; hydraulic measurements and efficiency of water motors; steam experiments on calorimeter; flow of steam; injector; steam pump, engine and boiler tests, etc.; and much time can profitably be devoted to strength of materials tests. Much of this work will be conducted in a less exhaustive way than if it came in the senior year of a college course, but that does not mean that it has any the less value in its place. An injector test, for instance, would be run to determine experimentally how much water one pound of steam would lift, and the results would be checked by the heat balance. The calculations involving the kinetic energy of the steam as it issues from its orifice would be omitted.

It may seem strange that I have not mentioned English in my outline of the course of study for the two-year Secondary Technical School, but I have not intended that it should be omitted from the course, by any means. In both years there would be required as a part of the laboratory work, a great number of written reports, besides considerable written work in mathematics and other class-room subjects, and from time to time more extended reports from current periodicals on assigned topics. All of these reports would be carefully criticised for expression, style, and good English, as well as for subject matter; the idea being that the best way to learn English is to write it continually and write on a subject with which one is familiar. These criticisms offer the best kind of instruction.

The following table shows more clearly than I can describe in words, perhaps, just what the proposed two-year course for the secondary technical school would contain, and I have chosen for my unit of comparison the *credit hour*, which corresponds to one recitation or two hours of laboratory or drawing per week for one term (one-third of the school year). In order that we may better understand the meaning of these figures, I have made comparison with the courses in mechanical engineering at two of the colleges of engineering in the country, and I have chosen the Massachusetts Institute of Technology and the Ohio State University as institutions having representative courses in different parts of the country.

	Secondary Technical School.	M. E. Course M. I. T.	M. E. Course O. S. U.
Drawing	30 crd. hrs.	37.5 crd. hrs.	23 crd. hrs.
Shopwork	30 " "	22.5 " "	22 " "
Mathematics	30 " "	24 " "	31 " "
Physics	15 " "	13.5 " "	9 " "
Physical Laboratory	12 " "	3 " "	4 " "
Mechanics, etc	15 " "	54 " "	68 " "
Mechanical Laboratory	12 " "	9 " "	13 " "
Language and other subjects not included in above	" "	70.5 " "	48 " "

The comparison shows that the Secondary Technical School would have about the same amount of mechanical drawing and machine design as the engineering courses, and considerably more shopwork. It would have the same amount of mathematics, but, of course, of lower grade; but more physics and physical laboratory. It would have only one-quarter as much time devoted to mechanism, mechanics, and other theoretical branches, but it would have as much time devoted to mechanical laboratory. No time would be available for languages, literature, political science or other similar subjects.

It will be noted that the total of time for the two-year course is more than half the total of either of the four-year courses, and it would appear that too much had been crowded into the shorter course. The difficulty arises, however, from the fact that there is so much larger a proportion of shopwork, laboratory, and drawing-room work in the shorter course—two hours of which not being the full equivalent of one hour of class-room work in a technical subject—that it appears more difficult, when in reality it is not.

THE EDUCATIONAL AND CULTURE VALUE OF THE TWO-YEAR TECHNICAL COURSE.

I trust that I may be pardoned in making the claim that it will be impossible to design a course that will have greater general educational value than the course above outlined when all its details shall be properly looked after. And by general educational value I mean power to broaden and develop mind and character and to prepare for life devoted to the best interests of society. I believe this because the course occupies the full interest and the full energies of the boy and develops, not one set of faculties, but all his faculties, senses, and muscles as well as mind; power of observation as well as power of reasoning; and power of doing as well as power of thinking. It will do this efficiently because by its simplicity energy is not dissipated.

The course will be broad and liberal if the men who give the instruction are broad and liberal, for breadth depends not on the subject, but on the way in which it is taught; and all those finer qualities which we are in the habit of associating with certain subjects depend in reality more on the personality of the men who teach them.

And, finally, the reason this course has the greatest educational value for young men whose life-work is to be in construction is, as I have already indicated, because the methods of reasoning and the habits of thought which they acquire in their school life they can go on using without interruption in their after life; and the process of development which begins in school thus becomes continuous through life, instead of ceasing when school is finished.

I hope, too, that I shall not be misunderstood in claiming as much cultural value for the technical course as for any high-school course, for I trust that old prejudice is done away with and knowledge in one field is as honorable as in another and that the day has come, or will soon come, when one will be as much ashamed of ignorance of Nature's laws as of ignorance of the sayings of men. Culture is largely the power of *nice discrimination* and the appreciation of things in their *relative proportion*, and these powers can be gained in the school machine shops or the laboratory as well as in the study of language or literature.

To What Does the Two-year Technical Course Lead?

It may be claimed by some that the course which I have outlined is superficial or that it leads to nothing special and that in the mechanical laboratory, for instance, things are attempted that are out of reach of the secondary student and far beyond the needs of one who is to enter manufacturing plants from the bottom. But let me ask, Is a common high-school course superficial because it is not a college course? Or is the study of Ovid or Virgil too pretentious for the high school because Latin is studied in college? Or are the things outlined for the work of the two-year technical student any farther beyond what he is likely to be called on to do and can do with confidence than are the elaborate designs of steel bridges or railroad construction or power plants or architectural designs beyond the student in the college of engineering? And are not these all parallel cases?

The two-year technical course depends for its strength (as does indeed the engineering course) not so much on the immediate utility of everything in the course—although the graduate has sufficient knowledge of mechanical drawing and machine construction to give him a considerable earning power in these lines—as it does on the training in the scientific method of thought applied to problems of the same kind that he is likely to meet all his life. And having acquired this habit of thought and the habit of never being satisfied until he knows the "why" for everything which he does, it matters little how, or how near the bottom, he may have to enter any industrial enterprise—in the draughting-room, the shop, or on the business or executive side—he will soon rise to something better. It is not supposed that the young man who graduates from this course will be fitted to fill the positions of foreman, superintendent, etc., which have been mentioned when he leaves the school; but turn a few hundred of these technically trained young men loose in our industries and see at the end of a few years if you have not some promising material from which to fill these high positions.

Training for Engineers.

In all the foregoing, care has been taken to make the distinction between a graduate of the engineering school and of the secondary technical school very clear, but I have not meant to imply that the profession of engineer is forever barred to the latter, although the path may be a long one. The distinction between the machinist or designer and the engineer is one through which no sharp line can be drawn. Many of our ablest engineers to-day have had no other training than the school of experience, and these young men who graduate from the two-year course will have had the path made easy and be started far along on the way. If only they keep on growing and developing, experience and perseverance will do the rest.

It is true that they have had no training in higher mathematics nor in mathematical theory dependent on the calculus; but this may not bar them. Professor Hutton pointed out in the *American Machinist*, in 1897, that there was a large class of engineers to whom the higher mathematics is not a necessity and to whom other branches are of much more importance; and again in the discussion of the paper on the "Education of Machinists, Foremen, and Mechanical Engineers," he called attention to the fact that the field for the engineer who is a "constructor" rather than a consulting engineer, is growing rapidly in this country.

This does not mean that we should decrease the mathematical training in our engineering courses, because for many lines of engineering work calculus is as necessary for a working tool as it is valuable as a mental discipline; and the student before graduation can never tell surely what line of work he will enter. But it does mean that there is a wide field of engineering where a cultivated judgment is more necessary than higher mathematics, and for such, other branches may be made more valuable as mental discipline than the calculus or abstract subjects dependent on it such as thermodynamics. To positions in this field of mechanical engineering those with less theoretical training may hope in time to rise.

The Two-year Electrical Course.

I have so far described only a mechanical course, but there is no reason why an electrical course designed on exactly parallel lines should not be equally valuable and serviceable and why the student who enters the two-year technical school should not be given the election between these two courses. In the course I have already described there is very little opportunity for anything in applied electricity without leaving out much that is of importance in other lines; and therefore the alternative course is the wiser method.

Such a course in applied electricity will in the first year be exactly similar to the mechanical course, excepting that perhaps the shopwork and drawing will be slightly reduced in order to allow time for a little elementary chemistry; while in the second year questions of practical and applied electricity would constitute the greater part of the laboratory and accompanying class-room work. Steam and power transmission by mechanical means, mechanism, mechanics, and strength of materials should not be omitted, but would be given in slightly more abbreviated form; but we should include a large amount of experimentation in the electrical field and time for the practical handling of electrical machinery. It would also probably be necessary, in order to make room for these, to somewhat reduce the time devoted to drawing and shopwork; and the work in both of these lines, so as to be closely related with the electricity, should perhaps be different in some of its details from that given to the mechanical class.

With the exception of these few modifications of the course, there is no reason why all I have said regarding the mechanical course should not apply with equal force to this course in applied electricity.

In Conclusion.

If there is anything of truth in the foregoing, it seems to me that the Society can do nothing that can be of more service to the community, to the profession of engineering, or for the welfare of the Society or its individual members, than by doing all in its power to promote the cause of the secondary technical education. It should mark out what it believes to be the wisest course and use its influence to have it carried out in the fullest and most thorough way, both through public and through private means, and should endeavor to see that only the fullest equipment and best facilities and instruction are considered good enough to meet the needs.

In no way, it is believed, can the Society do more for the cause of engineering education than this; for engineering is dependent on industrial prosperity, and nothing can be more essential for industrial prosperity than that there shall be trained and able subordinates able to coöperate with the men who direct at the top. The writer wishes to express his thanks to Messrs. A. L. Rice, J. M. Jameson, and W. J. Kaup, who assisted in the preparation of the *Pratt Institute Monthly* for May, 1900, from which in a few places extracts have been freely made for this paper.

ENTRANCE REQUIREMENTS FOR ENGINEERING COLLEGES.

Professor H. W. Tyler, chairman of the standing committee, stated that on account of the absence of members of the committee no formal report could be presented. The work of the committee for the year was outlined as follows:

Members of the Society will recall that at the Boston meeting of 1898, the question of attempting to carry out the plan previously outlined for undertaking the specific definition of entrance requirements in particular subjects and for making organized efforts to secure modification of the present entrance requirements in the direction of uniformity was referred to the council with the understanding that if considered favorably the membership of the committee should be enlarged. The questions involved were duly considered by the council of the Society during the course of the ensuing year and the following new members were added to the committee, viz.:

President F. W. McNair, Professor F. O. Marvin, Professor C. D. Marx, Professor J. C. Nagle, Professor R. B. Owens, Professor W. D. Pence.

This action was not taken, however, in time for any report to be made at the meeting of 1899. In taking the matter up the present year the committee has suffered serious disadvantage from the uncertainty as to the kind and amount of work it should undertake and the difficulty of exchanging ideas by correspondence alone. It should not be forgotten that the scope of the work proposed has been comparable in some respects with that of the large and important committees of the National Educational Association which have depended for their results upon appropriations which would be out of the question for the treasury of this Society even had the members of your committee been less burdened with their prior duties.

In November a letter was addressed by the chairman of the committee to each member, reviewing the previous work of the committee and requesting opinions and suggestions as to the manner in which further work should be prosecuted. Special emphasis was laid on the importance of correlating the work of the committee with that of others interested in similar ends. It was suggested that requirements in algebra and geometry be formulated first.

Replies to this letter were received from several members of the committee and copies of these replies were sent to the others with any comments deemed needful by the chairman. Without a detailed statement of the tenor of these letters, it is enough to say that the chairman of the committee remained still in doubt as to any immediate work to be undertaken.

In January the attention of the chairman was drawn to a movement of the Association of Colleges and Preparatory Schools of the Middle States and Maryland in favor of a joint college entrance examination board on lines suggested in a paper by Professor Nicholas Murray Butler. of Columbia University. Believing that the movement in question would promote the ends sought by your committee, the chairman addressed a letter to each of his colleagues calling attention to the plan in question and proposing that steps be taken looking toward coöperation between its advocates and your committee. After considerable exchange of correspondence between the members of the committee and the chairman, the latter addressed President Low, Professor Butler, and the officers of the National Education Association calling attention to the previous work of your committee and urging the importance of due recognition of the interests of engineering colleges and requesting that suggestions be transmitted in time for presentation at the New York meeting. The results of these negotiations while not yet very definite seem to the committee to be of fundamental value in the direction of emphasizing the importance of our interests upon the general educational organizations which must necessarily have the chief share in determining any comprehensive changes of college entrance requirements generally and any corresponding adaptation of the secondary work to such requirements.

It is probable that the delay of the committee's progress during the past two years has not been on the whole disadvantageous. The proposed formulation of entrance requirements has been carried on under the auspicies of the National Educational Association and the results of its work are likely to be of much value to us.

During the present week the committee has completed its organization by the appointment of Professor J. J. Flather as Secretary. It has been determined, as the main work of the coming year, to define and describe the several requirements for admission mentioned on pages 68 and 69 of the report presented at the annual meeting of 1896.

Discussion.

PROFESSOR MERRIMAN: As Professor Tyler has stated, this is not a formal report of the committee, owing to the fact that only four out of the eleven members have been presented at this meeting. It is to be hoped that during the coming year the committee may be able to take up the work of defining and formulating the requirements for admission. For example: when an engineering college specifies geometry, what is meant by geometry? If it specifies physics, how much does that include? If drawing is required, what kind? And how much? It seems particularly desirable that the committee should receive a great deal of assistance from members of the Society in formulating definitions of the requirements.

PRESIDENT MCNAIR as a member of the committee assured the Society that every possible means of coöperation is already under consideration, that the effort of the committee is not confined to institutions represented in the Society but that all are being considered.

PROFESSOR TYLER further stated that the expectation of Professor Butler, who was especially interested in this plan for a Coöperative Board, is that each college will accept, for the present, as an alternative for its own present requirements the standards proposed by the Joint Committee, and that the interest of the secondary teachers in preparing for that uniform standard will lead to its general adoption, whether all the colleges at first sanction it or not. For example, schools preparing applicants for Cornell, Columbia, Princeton, etc., will be particularly anxious to aim at the one standard proposed by the Joint Committee rather than at the four separate standards of these colleges.

PERSONALITY IN TEACHING.

BY JOHN P. BROOKS,

Professor of Civil Engineering, State College of Kentucky.

The curriculum of an institution indicates the minimum amount of knowledge required of a student for graduation, and it is not original with the speaker to say that this knowledge represents but one-tenth of a man's undergraduate education, the remaining ninety per cent. being inspiration. Such inspiration springs from many sources unknown elsewhere; the intercourse and hearty rivalry between so many equals, the undefined something called "college spirit" which continues beyond commencement day and revives with tonic influence at each annual reunion; the honored memory of eminent alumni which fixes and strengthens the determination to succeed and intensifies the abhorrence of possible failure. There is another source to which I refer especially in this paper: the principles imparted in the class-rooms by the personality of the teacher rather than by the subjects taught.

It is said that this busy, hurrying generation demands that education shall be confined to the intensely practical questions, and that its aim shall be to immediately enhance the value of the recipient as a wealth producing machine, that any other intent is superfluence and a waste of time. We are told with a confidence which defies contradiction that while the classics and so-called culture studies may do for such professions as law, theology, and the fine arts, they are too expensive luxuries to constitute a part of the make-up of an engineer's education. He must be taught, first, last and always, to do something definite. He must be taught methods and practices which make his services marketable immediately upon his graduation. These attainments with his somewhat superior knowledge of the reasons concerning them must enable him at once to be nearly as efficient and shortly to surpass the unlettered artisan.

It may be unfortunate, but it seems to be true, that the success of many technical schools is judged mainly by the time required by the graduates to secure positions. It is certainly true that, in the same institution, the course which leads, with the most apparent certainty, to independence without delay after graduation will attract the most students and those least welcome. Not that they are undesirable because of any lack of means to further prosecute their studies, or that they are not those in whom the refinements due to early association are marked, but that they are students of only moderate ambition and self-reliance, willing and hoping to make some sort of success through the mere circumstance of graduation from such a reputable school. When the time comes that such students are in the majority, the high repute of any institution is in danger of decadence in spite of all efforts on the part of the faculty or of benefactors.

The exacting demands of patrons for a marketable education makes a condition which technical instructors are bound to recognize, but the chief end should be such a broad foundation that the graduates will be quick to foresee what the public will need and be willing to pay for along engineering lines. There are many standards by which a man's capabilities are judged, and none that are entirely satisfactory or conclusive, but upon the whole, it is probable that their monetary equivalents in the open markets are the most just measures of one's gifts. Talent follows the beck of gold with little regard for personal preferences in other professions as well as in engineering. As long as the paying public demand the lightest literature, that is the field that will attract the bright minds of the men of letters, not because they could not write differently, but because it does not pay them to do so. The Sunday editions of our sensational newspapers are as ably edited as the deepest of our philosophical quarterlies. The stage furnishes countless examples of abundant talent expended upon productions of very doubtful merit at best, simply because the best efforts in this line bring greater rewards than do the best efforts in higher classes of drama. The professions of law, medicine, and theology are all strongly influenced by the desires of the practitioners for financial benefits rather than by any other variety of professional pride.

It seems then that the chief end of technical education is, and will be, to prepare men to add as much as possible, individually and collectively, to the material wealth of the members of the profession which they represent. This is at present the popular conception and I believe it should be accepted by teachers, except that we look a little further into the future for our estimate of a man's prosperity, and aim at ultimate, rather than immediate success.

It is as true of different professions as of different branches of any given vocation, that they attract the brightest and most ambitious young men, those of the best preparation and means enabling them to pursue any course of study most attractive to them, in proportion to the relative rewards offered to those who excel in them. When the time comes that the most eminent engineers of a city or a community receive as large fees for their advice or services as do the most eminent lawyers or the most popular authors or the most flattered favorites of the stage, then the students in the engineering schools will be as clever and the alumni will be as influential as their contemporaries in other professions.

We now have, in view of the necessity of greater earning power of practitioners of engineering, two propositions: first, as means toward that end, the attraction of the best element among students from other professions to that of engineering; second, the best possible methods of college training to prepare such students for successful careers.

It has long been recognized that in classical education the most faithful mastery of the daily tasks set by the instructor is not a reliable indication of the ability of the student to forge ahead of the average in the race of life. Not that the valedictorian will be outstripped by those far below him, but that the qualities which ensure success are not often largely dependent upon the information gathered from the text-books.

That what is true of classical is equally true of technical instruction, will be recognized from a study of the successes or failures of well-known men. It would be very difficult indeed to find an engineer who has gained prominence through knowledge found in text-books in college; that is but an item. Perseverance, ambition, honesty, high ideals, pleasing address, tact, vitality, good citizenship, and many other qualities are each more potent in shaping destinies than the difference between first class and ordinary instruction in physics, chemistry, mathematics, or drawing. These last are the tools of the engineering profession, and as such must be well made, of the latest designs and of well-selected material. The practitioner should have knowledge of the history, development, composition, and care of these implements as well as a familiarity with their use. He must learn the proper allotment to each variety, that an excess of one sort will not supply a deficiency in another, and must have them arranged in the most convenient order. These are absolute necessities of the engineer and no one makes a serious attempt to practice without being supplied. But still they are simply the tools, and the man with no other equipment is as far from being the highest type of engineer as he would be from being an eminent artist by providing himself with a quantity of paint and brushes and no other qualifications. He is simply "the man with the hoe," whose lot it is to apply his talents toward the consummation of the plans of others. He is the laborer, as distinguished from the worker.

That our technical schools will necessarily in the future, as in the past, number among their alumni many of this plodding type will not be questioned, but such a product cannot be expected to exert a very strong influence toward the uplifting of our profession as a whole. The industrial growth of the country demands that tens of thousands of young men be given a careful technical education in connection with detailed manual training. This system has been adopted in some of the European countries with astonishing results, and the same method must in time obtain here. This vast demand cannot be supplied from the graduates of our colleges, and I believe it to be a mistake to make the attempt. I believe that colleges have a different mission, and that they should apply their resources in an entirely different direction. One genius may add more to the material wealth of a nation than a thousand men of only average ability. There is abundant evidence of the truth of this statement. Colleges should aim to prepare their graduates for the only callings that are never over-crowded—the tops of all professions.

The school of the future which would seek the highest rank through the prestige of its graduates must promote the abstract as much as the concrete qualities which are indispensable for the highest measure of success. Students in engineering probably have less leisure time at their disposal than those in any other course. They are kept more closely to the exact requirements of the curriculum, with little encouragement to do outside reading. They have fewer opportunities of mingling together to discuss topics of current interest, or of broadening their conceptions by association with people of the world. The hurry and crowding of the technical courses cannot well be avoided without consigning some of the studies of the college to the preparatory schools and raising the standard of admission to the former. This course would, in many localities, be inadvisable because of the lack of good high schools and academies, and the present condition must be accepted as it is. The question hence arises, how can the abstract qualities so indispensable in the character of the highest type of the engineer and so marked in the lives of the most successful men in all professions, how can these qualities be most stimulated when inborn, and best supplied when they are deficient? I believe it to be of the highest importance that the teacher shall be of such personality that, while knowing that he receives a first-class technical education, the student unmistakably realizes that that is but a minor part of his college training. He must know that independent, accurate, and logical thought, together with untiring energy and the "infinite capacity for taking pains" are the essential factors in success. A college must, through its instructors, inspire in the student a confidence to think out any problem that may present itself, and courage to support his conclusions against conflicting arguments. The student must be inspired with a regard for truth for truth's sake, for no scientific research can be reliable if the explorer be of any other temperament. To educate a man without inspiring proper ideals regarding his relations toward his fellows, is like launching a rudderless torpedo boat. The more technical education such men have, the more desperate the case.

Students whose native talents are above the average are absolutely essential factors in the success of a school or of a profession, and no effort should be spared to attract that class, to the exclusion of all others, to our technical schools. This cannot always be done by raising the standard of admission, because we then get those who have had the greatest opportunities, rather than those of ambition and strength of character. There are two ways by which inviting inducements are extended by engineering schools to prospective students; the first is by the reputation and ability of the teachers, and the other by the extent and perfection of equipment and apparatus. The latter is, in too many institutions, held preëminent and the former of secondary importance. No institution has unlimited resources and the best disposition of the available means has to be given careful consideration. The choice has to be made of first-class instructors with a moderate equipment of material, or elaborate buildings and furnishings with less eminent supervision. Few responsible heads of schools would admit that either plan is followed to the subordination of the other, but I believe that to be the fact necessary. The whirr of moving machinery, the glitter of brass instruments and the showy display of appliances are all of educational use, inasmuch as they attract to college halls an otherwise untempted herd, among which some thoroughbreds may be found. I believe that too costly equipment is a positive menace to good college instruction; no student will ever do good work with an instrument for which he has too great respect; he will gain no better idea of the strength of materials from a $10,000 testing-machine than by stretching a beam between two chairs and loading it till it breaks. No effort must be spared to preserve the impression that it is the man and not the machine that is doing the work. The child returns contentedly from costly and ingenious toys to rough blocks, with which it constructs castles and steam engines and bridges and, in fancy, becomes the warrior or the engineer. The proper training of the imagination should be the end most sought for in college work. No amount of technical knowledge or of industry can raise the individual above mediocrity if he be deficient in imagination. The engineer may build a great bridge, of pleasing outline and of economic design, and, by so doing, accomplishes much, but the man whose imagination reveals the need of such a structure or the results dependent upon its completion is the one who merits and reaps the greatest reward.

These highest ends of college education cannot be gained except by offering such inducements as will attract the broadest men to the profession of teaching. Men are needed, who, by their personality, can impart the indispensable knowledge not found in text-books; men who are competent to teach engineering in its relations to other professions and to progress in general; men whose habits and environments will be examples of a pleasing prospect before the youth. It is men and not material that is most needed in education. Large additional equipment demands an increased number of young assistants, more of the work of instruction entrusted to immature minds, and an expenditure of resources which could be put to better use.

Discussion.

Professor Allen said that while he agreed with very much that had been said in the paper, he was not, perhaps, in agreement with all of it. It seemed to him that there would be some danger if educators confined their efforts largely to educating men for the top. The paper did not say how high that should be put. The speaker's own impression was that if there is a very broad, solid foundation underneath, the top is likely to be a little higher than if the man is educated for the top alone. There is a strong demand for men to fill positions below the top, and he believed it certainly to be the function of the engineering colleges to provide men of that sort. He had occasion only within a few days to suggest that perhaps one of the most valuable men was the man who was ready to fill, not a big position, but a small position, and he felt that the schools can afford to educate men who shall fill the small positions as well as the men who are ready for the large positions, and that it will sometimes be found that the man who has filled the small position will succeed, after a time, in over-filling it, and finally be pushed up to the top.

The speaker remarked that it was the common experience to find that some man who did not shine in his first year or two in the engineering college does in his third or fourth year develop a strength which puts him among the best of his class. The history of some of the most successful men has been of that particular sort. He thought there was danger in working to educate men for the top alone, or for the top especially; that the world has need, at the present time, not so much of brilliant men, as of men who can be depended upon. He found the greatest difficulty, in various directions, in getting hold of men who can be depended upon. In the work of the household, in building, or whatever it may be, this lack is, to-day especially, apparent, and the engineering college has a large field in getting ready for the world men who can be depended upon, and not merely men for the top.

Professor Gray thought there was a great deal in what Professor Allen had just said and that if all the attention is devoted to those who are able to go further than the average, a large waste of the facilities of the institutions will result, and our duty will not be done to the country at large. The average man should get a great deal of our attention.

One point which struck the speaker was the danger pointed out in the paper of running too much into fancy equipment and of valuing institutions because of the great cost of the equipment to the exclusion altogether of the personality of the men who are doing the teaching. It is undoubtedly true that the student who has to contend with difficulties in doing experimental work, and who overcomes these difficulties successfully, is likely to be a better man afterward. It had been his experience that the men who have had to devise means for carrying out their experiments are the most valuable men. There is no doubt an advantage in having everything at hand, but in such cases it very often happens that after a student has been directed through an experiment by his professor, he knows very little about it.

Professor Ayres said that in considering the function of an engineering college, we should never lose sight of the fact that we are to look first to the good of the community, and then to the success of the individual. Genius will make itself felt. In the matter of equipment, the speaker wished to be understood as endorsing very fully what had been said. It seemed to him that some of the schools were in danger of running to fads, and that very valuable work might be done by this Society if at some time a thoroughly scientific study were made of the character of equipment which is demanded by a technical school. The fundamental principles seemed to be clear enough to make such a classification possible. An express train or a locomotive, or some particular phase of enterprise, furnishes something which is very attractive to the visitor, and is noted in the papers, but it seemed to the speaker that it is distinctly a lowering of the ideal of the institution if those in charge will allow this to lead to the exclusion of that character of equipment which is useful in impressing the student with the fundamental laws, the application of which is the work of his profession.

Professor Thomas thought that there was one point brought out in the paper which all would endorse, and that is the importance of impressing upon the engineering student that the humanities ought not to be neglected; that is, while teaching the practical, the fact that "man does not live by bread alone" is not to be lost sight of. The engineer should not be placed above the man. Darwin in his later years said that he had so devoted himself to his special work that he had lost all taste for music, painting, and poetry, of which he was particularly fond in his younger days, and he expressed regret at the lost interest in Shakespeare which intense application to one line of work had inevitably wrought.

Professor A. W. French noticed that there was a tendency to rob from the corps of instruction and to put the resources into equipment and machinery. If there is money to put into machinery, well and good; but it is apparent that in many schools the amount of instruction given by cheap assistants, poorly-paid men who have just graduated, is a very bad feature, and that if money be available for equipment and not for able assistants, the line should be drawn there. There should be money for the personality, for men of some practical experience and value, and the question of equipment should be secondary.

Professor Jackson expressed his interest in the foregoing remarks in reference to equipment being a secondary matter. It was his conviction that there are too many ill-chosen subordinate teachers in the engineering colleges. It is frequently thought that when men cannot make a success in business life, they are just right for teaching. The speaker thought this view of the matter was entirely wrong, and should not be allowed to grow in any modern technical college. The man who has made a failure in business life will certainly make a failure in teaching engineering. Enthusiastic men are wanted; they may be young men, but they must be paid well enough so that they may be self-respecting members of their profession, and they must be properly chosen with respect to their qualifications. With men of this character, the speaker was absolutely sure that it would be necessary to have good equipment, in order to obtain and keep them. He would not continue to teach engineering if he could not have the equipment.

The result of making a spectacular show of equipment is to give the engineering student an entirely wrong impression. The material with which he works, as well as the machinery, should be of the best grade, and it should be operated in very much the same style in which he will be expected to operate it in his future engineering practice, and he should be expected to handle it with just as much care as he will in the future, and no more. If he damages it, through carelessness, he should be made to stand the consequences, in some way. Apparatus that is properly selected is just as important as the teacher, and is by no means a secondary matter, but the apparatus that is selected for the purpose of making a show, rather than for the purpose of making a good, solid impression upon the student, is entirely wrong.

PROFESSOR LANZA said that any teacher of engineering would welcome an improvement in his equipment, wherever the means of accomplishing it were available. He said that, in all teaching, whether by means of class room or laboratory methods, the character of the instruction should be such as to give to the students impressions of the truth, and all false impressions should be avoided. Hence, breaking a small beam upon two chairs so far from being as valuable as testing a full size beam is calculated to do harm, as it would convey an erroneous impression of the behavior of a full size beam, and such erroneous impressions are harmful.

Whether the experiments in the laboratory are on a small or on a large scale, they should be on the same scale that occurs in practical work, the conditions should be those of practice, and they should be accurately made, so that the conclusions drawn from them may be correct, and may apply to practice, and give the student correct impressions of what occurs in practice.

Experiments made in this manner require a suitable equipment and are of value in the education of the student. If they are not so made they are not of value, and are often harmful.

Professor Johnson thought that it would be sufficient to fix two or three items in our minds on this subject. It is impossible to get proper personality without reasonably good equipment. To-day the demand for proper personality in engineering colleges is so great that the right man for the place will not stay unless the conditions are right in this respect. He can be called elsewhere very quickly if he is given insufficient inducements and meager appliances with which to work. The speaker argued, therefore, that a reasonably good equipment is absolutely essential to obtain and retain the proper personality. It is quite possible to have the equipment without the personality, whereas you cannot long have the personality without the equipment. That is where one sometimes gets left; it is not always possible to get rid of our personalities, but, the equipment in hand, the instruction force can usually be kept. The trouble is to eliminate the wrong personality, and the speaker thought that the wrong personality in an instructional force should be eliminated just as promptly and just as conscientiously as it would be eliminated in any other kind of business. The interests of the students are paramount, and the man who is inclined to force himself and his continuance beyond the stage of usefulness deserves very little consideration ; it is often necessary to be cruel to the man in order to be just and kind to the student. If the interests of the student are paramount a good many disagreeable things must be done. However, the right man cannot be obtained without the equipment, and if the right man is not in the place, he should be sought.

Professor Brooks was of the opinion that Professor Allen had misunderstood his remarks in the paper. He thought there should not be any conflict between the college and the manual-training school, because there are so many men needed in developing the resources of the country. The colleges should leave some of the work to the schools of manual training.

BUSINESS METHODS IN TEACHING ENGINEERING.

BY ARTHUR L. RICE,

Professor of Applied Electricity, Pratt Institute.

The relation between the engineer and the business world is very close, in fact, so close that engineering is more properly called a business pursuit than a profession. To be sure, it is a business which, in the constructive work, requires much special knowledge and training, and it is equally true that the mere buying and selling may be done by those with but little technical learning; this is true, however, of many kinds of manufacturing, and the fact remains that the technical man, to be capable of the best work, must understand and appreciate the financial considerations which necessarily influence his designs, and must use business methods in the conduct of his work. He must so plan his work that the designs and drawings may be quickly made, and easily consulted at any time for revision, alteration or extension: his designs must be so made that the construction can be accomplished as easily and cheaply as is consistent with the end in view; he must use standard commercial parts and material wherever possible to reduce cost. All this makes it necessary that he should have a large amount of information at hand, in such shape that it can be easily consulted, revised and increased: that this information shall relate not only to the facts and principles of science and engineering, but to the best methods, past and present, of doing work, where and when material and parts can be obtained and their cost, the cost of previous work of any kind, and innumerable other details which enter into the engineer's daily work. One man will have need of knowledge largely technical, another of that largely commercial, according to his position and the subdivision of work adopted by the concern by which he is employed, but the general conditions are the same.

This being true, it is obvious that the sooner and the more thoroughly the engineering student can acquire habits of looking at the commercial as well as the engineering considerations of a design, of doing his work systematically and of preserving knowledge for future reference in a convenient and systematic way, the better for him, for his teachers and for the world at large. And not only will the habit of systematic and business-like working be of value after the class-room has been left behind, but during the course, the time saved by methodical procedure on the part of teacher and student will more than compensate for the effort necessary to acquire the habit. This is an important consideration, because technical courses are necessarily crowded with work, and a student is expected to learn in his college course as much of engineering principles, precedents and current practice as a man in an office or factory learns in half a lifetime; certainly, unsystematic work on the part of teacher or student must result in confusion and bewilderment in the mind of the student, and his utter inability to digest, at the time, the matter presented to him or to get a clear idea of how to acquire a knowledge of it in the future.

The arguments for system and method in doing work seem sufficiently strong; the student must get them eventually, and had better get them early in his work; time and labor can be saved for both student and teacher by their use; and the knowledge gained will be better understood and remembered. Since systematic methods should be adopted, it seems better, so far as possible, to take those employed in the business world; the student will find them useful after graduation, and they have been developed under conditions where systems must be good or be discarded. There should be one difference; business systems are worked out primarily to save time and expense without regard to the effect on those using them; the aim of the systems used in a technical course should be, first, to train the student to think and work systematically on his own account in order that, second, he may save time and effort and avoid confusion. The most obvious places for the introduction of business systems and methods are the drawing-room and shops, because there the work seems, at first sight, to be more nearly akin to that of the business world than it does in class-rooms and laboratories; but it is no less important in the latter places than in the former. Of course, in the drawing-room systematic methods of arranging views, dimensioning drawings, making sketches and computations, and indexing all work, either preliminary or final, should be insisted upon, and a regular system of filing and indexing drawings should be adhered to. Also systematic procedure in making and inking drawings, and systematic methods of looking up past practice, comparing equations of various authorities and calculating proportions when designing should be taught. In the shops, systems should be used for keeping track of tools, of material used and time spent on all work, and of the progress of all work on which the students are engaged.

In the class-room work, the student should be urged, even compelled to keep a neat and orderly note book containing all important facts, equations and tables which are taken up in the course of the work, so that they may be readily referred to by him. He should be taught to solve all problems neatly and systematically, to analyze a problem before beginning the computations, and to preserve *all* data and computations; all problems handed in to the teacher should be in a standard form and on standard paper.

In the laboratory, all original readings should be preserved in a note book kept for that purpose and should be inspected by the teacher to make sure that all needed observations are taken and that the work is done and recorded systematically. Reports should have a standard form of arrangement; curves should be in a standard form and with enough data always given so that the curve, if separated from the report proper, would still be of value. The writer is of the opinion that it is better to use a standard arrangement of report than report blanks, because the former practice requires the student, of himself, to be systematic and cultivates his sense of orderliness and responsibility, while the latter only calls for the routine completion of another's system. It may be advisable to use blanks in a few of the earlier experiments of a course, until the student acquires the spirit of orderliness; and for a certain class of experiments, such as engine and boiler tests, the saving of the teacher's time in making corrections warrants their use, but it should not be the common practice. A definite time for the handing in of laboratory reports and class problems, both for the first reading and after revision, should be insisted upon, and a regular method of correction, using a set of symbols saves much time and trouble. In this connection, the student should be taught, so far as possible (and I say this with a full realization of the difficulties involved), to work outside as well as inside of the class room by a regular schedule, keeping track of the date when work is due and of what work should be done each day. He should be taught by requiring it in his own work, and by example in the work of his teachers, to file and index all data and problems for future reference, and to adopt methods for this likely to prove adequate to future needs. In all systems, the aim should be simplicity and efficiency; in the business world, a system is always made as nearly automatic as possible, and the same should be true for a good school system; but where the work of one student only is involved, as in the indexing of his notes and experiments or the filing of data, examples of good system should be explained and as much individuality allowed as possible, the possibility depending largely on the ratio of the number in the teaching force to that of the students. In any case the teacher must keep in mind the fact that the student does not know how to form a system, in fact, does not know what system is until it is explained and illustrated, and care should be taken that the examples chosen are good and standard models. Such models are used in nearly all business concerns for shop, drawing room, testing room and office records, and these systems, possibly with slight modifications, are well adapted for use in the same kind of work in technical schools and colleges.

Lastly, I would call attention to the advantages to the teacher of systematic methods in the conduct of his work. Usually the conscientious teacher does not consider the effect of any proposed course of action on himself so much as its effect on and value to the student; but, when advantage to the student is linked with saving of time and worry to the teacher, the advisability of adopting a given course is made doubly strong. Is it not evident that a great saving of time will be effected in the correction of exercises if all of them are uniform in their arrangement? Will not the worriment about work be reduced if it is always evident what should be done next, and when the day's work is finished? Is not the problem of handling large classes simplified by a thoroughly systematic method of keeping track of their work? If we are to preach system and method to the student, we must lead him by example and practice; our own work must be as systematic and orderly as we would like his to be; and this necessity, if properly met, works to our advantage.

In conclusion are appended some examples of systems which are in use at Pratt Institute; they are given, not because they are perfect, but because it is thought that they may be helpful to some of the younger members of the Society, and may lead to suggestions from the older members. The shop ticket which is here shown was devised by Mr. W. J. Kaup and fulfils its purpose admirably; each piece of work is given a shop number which is placed in the first column, the kind of work done is placed in the second, the time spent on the operation in the third and the cost in the last, the student's time being estimated at its market value. A ticket is filled out each day by each student, and at the end of the year, the total amount of any material used can be gotten from the tickets and also the purposes for which it has been used. The only alteration which the writer would suggest is the addition of a column for the name of the piece as well as its shop number.

For the drawing room, the methods used in the best factories are unquestionably the ones to be adopted; third angle projection, shade lines where desirable, plain dimensioning, standard lettering and a decimal system of indexing are good practice. The writer believes that dimensions should be, so far as possible, put outside of the drawing proper in order to avoid obscuring and confusing the outlines. The classification to be adopted for an indexing system will vary with the kind of work done, and here is a place where the individuality of each student may well be allowed to enter largely; the Dewey system, the Cutter system and the system proposed by Professor F. R. Hutton are good models to follow.

For laboratory records, the following order is used:

1. Dimensions and data from measurement.
2. Dimensions and data from books and records and their source.

3. Tabulated readings and observations and corrections to be made.

4. Final dimensions and data.

This order is observed in recording the values in the student's laboratory record book, in the report of work which he hands in when leaving the laboratory, and in the record of his observations in the laboratory report. The records of observations are kept in a book of convenient size to be carried in the pocket, much the same as the one used by Professor Caldwell and shown to the Society at the Boston meeting. The preliminary reports of observations are all filed and are often found valuable for reference. The records must be paged and indexed, and the indexing must be kept up with the subject matter of the book. Reports are arranged in the following order:

1. Number and name of the experiment.

2. Explanation of the manner of performing the experiment, including diagrams of apparatus and connections.

3. See 1 and 2 of record form.

4. See 3 and 4 of record form.

5. Method of working up results and making computations.

6. Results in tabulated form.

7. Curve plotted from results.

N. B.—Curves must be drawn on special cross-section paper; each axis is to be labelled with the name of the quantity represented and the units in which it is measured, and divisions at one-half inch apart are to be numbered. The scale should be so chosen that the divisions will represent even numbers and had better be on the decimal system. The lower and left hand margin lines must be used as axes and the independent variable put on the horizontal axis. Points should be indicated by the center of a circle or by the right-angled crossing of two fine lines. The title of the curve should tell, what it is, when taken, from what apparatus and under what conditions.

8. Remarks on difficulties encountered or peculiarities noted.

Conclusions drawn from the results of the experiment and answers to questions on the direction sheet.

These reports are due seven days after the completion of an experiment, and are to be corrected and accepted within five days after that. For a system of correcting symbols, the writer prefers the initial letters of words such as R for reading wrong, M for method wrong, G for grammar wrong, E for equation wrong, etc., since they are more easily carried in mind than are arbitrary ones. Reports are made on sheets of standard letter size, and are handed in separately for each experiment; after acceptance, they are filed in a note cover and indexed. If reports are not presented when due, a penalty must be inflicted, the character of which should depend on the nature of the work and the maturity of the students. The method adopted of keeping track of the reports has been to require from each division, at the end of a period, a slip containing the date, the division number, the experiment number either "completed" or "not completed," as the case may be; if an experiment is not completed, the slip is put in the memorandum file for future reassignment, or else the division is continued on that experiment, the latter being the preferable course. If the experiment is completed, the slip is stamped "report due" seven days ahead and "corrections due" twelve days ahead, and placed in the memorandum file; the date of completion is stamped on the records of all students in the division. When the report is received and likewise when it is accepted, the date is stamped on it and on the student's record. Samples of the slip and of the record used are given below. The student's records have been kept in a card index, but it is thought that the use of a large sheet which will take the record of more experiments will prove less laborious, the system of keeping the record and of filing being the same.

For problems, much the same system is used; the order of arrangement is:

1. Number . . . Name of student . . . . . Date . . . . .
2. Date of the problem.
3. Method of solution and equations used.
4. Solution and computations.
5. Answers.

The date when the problem is due is put on a slip and placed in the memorandum file; if the solution given by a student is not correct, five days are allowed for revision. The problem is stamped with the dates of receipt and acceptance, and these are also put on the student's record in the same way as for a laboratory report.

In the routine of office work, the systems adopted are, as nearly as possible, like those of a commercial office. Records, data, problems, laboratory directions, etc., are put in letter files and indexed; references, clippings, notes, lantern slides, etc., are filed in a large card index and drawings and blue prints are filed in cases, all being indexed by the decimal system. In keeping track of work due, and of details which should receive attention, and in the planning of future work, a daily memorandum file has proven extremely useful. This is indexed alphabetically, numerally and monthly, the monthly file being separate. Memoranda of all matters which should receive attention at any time during the present month are filed under the proper day; those requiring attention during some month in the future are filed under that month, and, on the first of that month, are transferred to the daily file. The alphabetical file is used for matters which require attention at some indefinite time in the future. This form of file is for sale by several makers of office furniture.

For keeping the entire record of a student the following form of card has been found convenient; it is an adaptation by Professor Arthur L. Williston of a form of record which has been used elsewhere to the work of the Institute. Monthly reports and the term examination mark are placed on the right hand side of the subject column, and term records made up from these on the left hand side. If the work of a term is not completed satisfactorily, no term mark is entered, so that a glance at the three left hand columns will show whether a student's record is clear or not, and the right hand side shows at any time whether his work has been improving, deteriorating or holding steady. The lower lines are used to record extra work done, either voluntarily or to remove a condition. An examination of the card will show that a place is provided for almost anything that can possibly be wanted on record in regard to a student.

Any system, to be satisfactory, requires strict attention to its details on the part of those using it, but a system, though imperfectly carried out, is better than no system, and a good system, well carried out, is sure to reduce the time and labor required to carry on any work. The systems which are adapted to the work of one school or college may not be to that of another, and each one must work out his own salvation through thought and trial; but some system for all parts of the work of an engineering course is certainly due to the student both for his own sake and that of the teacher, and the writer believes that the methods of carrying on work which have been found best in business will prove best in teaching.

NAME: *Clarke.* DIVISION: 4.

EXPT. NO.	49	50	51	52	53	54
FINISHED	Jan. 9	Jan. 16	Jan. 19	Jan. 8	Jan. 4	Jan. 5
RECEIVED	Jan. 15	Jan. 24	Jan. 26	Jan. 15	Jan. 12	Jan. 15
ACCEPTED	Jan. 15	Jan. 30	Jan. 26	Jan. 15	Jan. 12	Jan. 18
RECORD	B + 2	C + 2	A + 2	A + 0	B + 6	C + 2

DIV. 3, EXP. 98, F. R.
Date, June 15.
COMPLETED.
Report due June 22.
Correc. due June 27.

DIV. 5, EXP. 100, F. R.
Date, June 20.
NOT COMPLETED.
June 21, 1900.

PRATT INSTITUTE.

DEPARTMENT OF SCIENCE AND TECHNOLOGY.

Name: JOHN SMITH.
Home Address: BROOKLYN, N. Y.
Name and Address of Parent or Guardian: JAMES SMITH.

Course: APPLIED ELECTRICITY.

Born, 6-17-1878.
Entered, 9-26-1899.
Left.................................
Returned ....
Graduated ....

TERM RECORDS.			SUBJECT.	INTERMEDIATE REPORTS.											
First	Sec.	Third	First Year	Oct.	Nov.	Dec.	Exam.	Jan.	Feb.	Mar.	Exam.	Apr.	May	June	Exam.
C+	B	B	Chemistry	B	C	C+	85	C+	B	B	85	B	B+	B	80
C	C+	B+	Chemical Lab.	C	C	C+		B	C	C+		B	B+	A	
	C	C	Physics	D	C	D+	70	C	C	C+	70	C+	C+	C	75
	C	C—	Physical Lab.	D	D	D		D	C	D		C	C+	D	
B	B	B	Mathematics	B	B+	C+	85	B	B	B+	80	B	C	B+	87
A	B+		Woodworking	A	A	A		A	B	B+		A			
		A	Foundry										B	A	
			Forging												
C	C+	B	Mech. Drawing	C	C	C+		C+	C+	B		C+	B	B+	
			F. H. Drawing												
			Times absent from Recitation	0	2	0		1	3	0		1	2	1	
First	Sec.	Third	Second Year.	Oct.	Nov.	Dec.	Exam.	Jan.	Feb.	Mar.	Exam.	Apr.	May	June	Exam.
			App. Electr.												
			Electrical Lab.												
			Mech. Drawing												
			Mechanics												
			Mathematics												
			Forging												
			Machine Work												
			Machine Des.												
			Mech. Lab.												
			Times absent from Recitation												
First	Sec.	Third	Extra Work	Oct.	Nov.	Dec.	Exam.	Jan.	Feb.	Mar.	Exam.	Apr.	May	June	Exam.
		B	Physical Lab.	To remove condition second term B											

ENTRANCE RECORD AND PREPARATORY TRAINING.

English Exam.	90	June	Sept. 90
Arithmetic Exam.		June 60	Sept. 80
Algebra Exam.		June —	Sept. 75

H. S. Diploma from Year
Time spent in H. S. Left
Gram Sch. Diploma Year
Time spent in Gram. Sch. Left

Practical experience: 2 years machine shop

Remarks.

A means Excellent.
B " Good.
C " Fair.
D " Unsatisfactory.
E " Deficient.
+ After a letter means a tendency toward the next higher Mark.

PRATT INSTITUTE.

DEPARTMENT OF SCIENCE AND TECHNOLOGY.

S. & M. D. Class. May 20, 1900.

SHOP No.	DESCRIPTION OF WORK.	TIME IN HOURS.	COST.
20	Turning	3	45c.

Material__________ ____Lbs.

Name: *Smith, R. E.*

Discussion.

Professor Caldwell (by letter) urged the importance of right habits in taking notes of tests. Perhaps the scientific departments present the greatest shortcomings in this matter, but even some engineering departments allow their students to take notes in any note-book or even on any scrap of paper that may come handy; from this form the notes are copied and handed in, in a shape as neat as it is unreliable.

The student should have it impressed upon him from the start that data in its original form is much more valuable than after it has been copied and that it should be taken at the start in such a form and with such neatness and fulness, that it will be as comprehensible at any later time as it is when taken. He should be taught to have for his note-book the same regard that an engineer has. To assist in forming good habits in this matter the practice of requiring a standard note-book, of good quality, is useful, such a note-book, for instance, as was described in my paper before the Boston meeting, and of which the use seems to be extending. Reports should of course be required, but the greater stress should be laid on recording and working up the notes in the note-books.

PROFESSOR JACOBY wished to bear testimony to the importance of this subject, and to emphasize a few points. The first item concerns the usefulness of outlining the work previously so as to let the students know what is to be required. They will labor with much more interest when they know what is covered by the course. The speaker said that during the past year he learned, by conversation with students, that in some instances they had been expected to perform work which had never been brought to their attention, and only by conversation with others who had apparently made inquiries were they able to learn that certain work was required. Sometimes this could have been done more easily if it had been brought to their attention beforehand. The speaker had found by experience that the use of printed direction sheets is advantageous. In some of his work he had at first given very slight directions as to the order of procedure in designs, computations, etc. This was done, principally in lectures, but he had found later that, by printing sheets for the use of every man whether present at the lecture or not, a more desirable result was attained.

He had also tried another scheme in regard to securing systematic work from the student in response to the query as to what shall be done with the man who is always late in handing in his reports. Since in practice, penalties are often attached for overdue contracts, it seemed possible that something might be done in this way to take care of late reports. It has accordingly been his practice to announce to the students at the beginning of the term that for every day's delay ten per cent. of the credit allowed for the report would be deducted. Experience shows that this gives thorough satisfaction to the students, because it gives them something definite to work to. It helps to keep their work up to date and not a single student has objected to the plan. Then there is the matter of writing reports arranged in the order in which the several topics are naturally presented. It is certainly a great saving of time to the examiners to have the reports in together and uniformly arranged in their subdivisions, for by simplifying the work by a systematic arrangement the examinations may be made more thorough, and the errors fully pointed out to the student.

Professor Johnson stated that the paper had interested him, and expressed the thought that the author should add copies of the blanks to the paper, so that they may be printed together.

Professor R. S. Woodward said he was inclined to praise the work of the card catalogue, but it had been found at Columbia University that some of the instructors were not as good bookkeepers as they were instructors, and the inquiry had been made as to whether the instructing force were bookkeepers or instructors. Hence, with the advent of this admirable system, it seemed to the speaker that some attention should be given to divesting it of some of its complications. For instance, here is a table requiring some fifty or sixty entries to be made; shall some bookkeeper do this, or shall the instructor do it?

Professor Rice responded that the clerical work is all done in the office.

Professor Woodward stated that there may be clerks, and other clerks, but finally, some one should see that no mistake has been made.

Professor Rice explained that the record is made in the office from the monthly reports of instructors, and that later the report is considered in the faculty meeting so that if there are any mistakes in the record they will come up at that time.

Professor Woodward remarked that at Columbia it is found that the mistakes are not discovered by the instructors, but by the students. Therefore it would seem that with the introduction of business methods into our systems of bookkeeping, while they can be generally approved, caution should be exercised not to convert the student, and especially the instructor, into mere bookkeepers and machines for running machines. In fact, this is a great difficulty. The modern high development leads to the effort to make machines run themselves, and it is forgotten that, after all, it is not so much the business of the instructor to look after the delinquent students, as to make it advantageous for a few of the rather good fellows to learn something.

Professor Williston explained that the particular card in question was designed for general office use, and was kept filled out by a record clerk whose business it is to get just that one thing, and its object is, more than anything else, to save time and bookkeeping on the part of the instructor and director so that one can tell at a glance the name of the student and the amount of work done and its character, and whether he is advancing or not. Where there is a large number of students with whose work it is necessary to keep in touch, this information is needed in just such a shape that it may be seen at a glance. There is first the record by months up to the end of the term and at the end of that time the record is condensed into a single slip, so that when looking for a record for the entire year, one looks for the term mark instead of the monthly mark. The speaker said he had found this method very convenient, and had been able to keep track of several hundred students in their work by having some such cards before him and going over them very rapidly.

Professor Allen said that inasmuch as criticism had almost been invited upon the question whether engineering was a business or a profession, it occurred to him that it might be well to call attention to the definition given by Col. Prout, in which, as the speaker remembered it, the statement was that the man who was a member of a business concern was, in general, looking after his own interests, while the member of a profession was, in general, looking after the interests of his client; it seemed to the speaker that this definition serves pretty well to show the line between the two.

Professor Williston added a thought that occurred to him, with reference to the question whether the engineering profession was becoming a business, or whether many lines of business were not, really, becoming professions. According to the definition just quoted by Professor Allen, it seemed to the speaker that a great many business positions are really professions. Any officer in a large corporation is not looking after his own interest at all, but the interests of others, in very much the same way that the professional engineer is looking after interests. It all amounts to the same fact, that the so-called business methods and the engineering profession are coming closer and closer together.

PROFESSOR LANDRETH thought that it was well recognized that at present the best preparation for an administrative career in any of the industrial lines and in many of the commercial lines was the training received at an engineering school. Of the two tasks: To give the business man sufficient technical training, or to give the young engineer sufficient business training; the latter was unquestionably the simpler and the proper alternative. It is too much to ask that the business training shall be acquired after college life ends, and until the proposed College of Commerce materializes the proper plan would be to incorporate into the course of instruction of the engineering school the fundamental principles of administration. The matter thus became pertinent to engineering education. Although the present paper dealt more particularly with the economic matter of time-saving in college or at the engineering school, he thought that its educative effect on the student was by far the more important. The speaker sympathized fully with the fear that the system, where not intelligently planned and executed, might easily transform its user into an automaton, or might similarly consume more time in operating it than it saved, but did not think that this should prevent a recognition of its very evident merits and felt sure that the prospective dangers would be perceived and avoided by intelligent consideration and discussion, and that in the long run it would not only prove a valuable feature of business training, but a time-saving device during the school period as well.

Mr. Snow expressed the belief that particularly in the mechanical and electrical engineering courses one of the best opportunities for instilling systematic methods is in the making of drawings. It had been his privilege to see the inside working of most of the technical schools of the country, and he had been impressed with the general lack of system in the treatment of what might be called shop drawings. Of course, many of the institutions are following admirable systems as regards size, lettering, etc., but it is true that there are others in which drawings can only be found after a search: they are in such sizes as best suited the individual making them; they lack numbers; the lettering has a fantastic style, varying according to the differing tastes of the draughtsmen, and they are, altogether, as far away from the shop practice as can be imagined. The speaker mentioned these as exceptions, and stated that he believed it was true that the day of making hair-line drawings has passed by; but asked whether that stage was reached where it was realized that the free and full line, and clear dimensions and simple lettering, all go toward making the best shop drawing. The original drawing or tracing is hardly to be found in any of the shops of to-day; the blue print serves the purpose. In connection with the work of some technical schools, the speaker also thought there was an opportunity for improvement in classifying the patterns. Many of the schools are adopting a regular system, following methods of systematically filing them under such conditions that they may be readily found. All of these things instill into the student some idea of the problems he will meet in his daily life after graduation. The student who passes out of the mechanical or electrical engineering school without having had this contact with system and method is handicapped to just that extent. The speaker did not think that this adherence to method increases appreciably the work of instruction, but that it systematizes it. Systematic methods will always benefit the student.

Professor Gray was impressed with what Professor Woodward had said upon this matter. It appeared that the final records were made by a regular clerk, but those records cannot be made out without an original record, and it seemed that this was simply multiplying the records. There must be something from which to copy. The speaker's experience was that it comes back, finally, upon the instructor. If the instructor does not keep the records accurately, they will never be accurate. In the institution with which the speaker was connected very much the same plan was followed, the instructors handing in records to the office and from these the final record is made up. One of the constant sources of complaint arises from the fact that many instructors are not good bookkeepers. He had met with the remark, "Well, it may be very simple to you, but it bothers us a good deal." There are a great many men who can never be trained to bookkeeping methods.

Professor Jacoby thought it might be well to recognize that the stenographer and typewriter should have a part in such work, and it seemed to him that a great deal of work might be turned over to the stenographer.

Professor Woodward believed that this would not solve the difficulty; that it still goes back to the instructor.

Mr. Cilley emphasized what Professor Woodward had said. His impression of the paper was that the author would reduce teaching to a formula. He thought that system was very necessary indeed, but believed that anything that tends to eliminate thought is a mistake. In two great industrial establishments in which all the work was systematized to a very high degree the speaker had personally observed the consequent evils. In these instances systems resulted in reproducing not only all the merits of drawings kept as models or standards but all their defects as well. He thought it was very objectionable when systematizing resulted in anything of this sort.

Professor Magruder said he was familiar with the method where the instructors hand in reports on prepared blanks for the purpose, and records were copied from them for a full four years of the course. He had recently had occasion to compare this method with the practice which obtained in an institution ten years previously, and it was impossible to find out the bare facts. There were abbreviations and symbols which possibly only the person in charge of the records at that time could elucidate, but which no one else, not even the student himself, could translate. This present system under discussion gives one, then, the entire record on one sheet for the four years of the course, and is an admirable method. One of his colleagues carries this a little further; after the student has left college, the professor goes to his private card catalogue and inserts a card on which is given the man's record in a few words from time to time, he jots down on the card where he first was employed, the time he stayed there, his subsequent employment or occupations, items of interest concerning his successes and his life. Some years later the student visits his old college and calls on his professor in his office. Immediately the card catalogue comes out, and the professor looks up the man's record and incidentally asks him questions as to his life since he left college which complete the biographical record, and at the same time it pleases the man to find that his professor seems to have remembered him.

The speaker wished to inquire if there was any object in having the cards of different colors as shown by the samples exhibited; and would it not be better if there were not such a great diversity of sizes?

Professor Jackson remarked that perhaps he was a Philistine on this subject, but it seemed to him that there are two problems, one of which is to take care of the elementary student. In this case he imagined that the monthly records were a good thing. When it comes to the second problem, which is to take care of the engineering student proper—the junior or senior—it seemed to him that it is well to spend the time in teaching him and bringing him to a responsibility for ultimate results rather than in keeping figures on his progress. The speaker said he formerly kept a record book, but he had given it up a long time ago, because he believed better results are obtained by telling the student that he must come up to the scratch at the end and that he will not receive any credit at all if he has not a satisfactory working knowledge of his subject when the end of the term comes. There are only two classes of people who can afford to be slouchy—the independently wealthy man, and the cowherd, and the engineering students must be taught this. It had been his experience, that students can be taught the importance of producing satisfactory ultimate results which give evidence of promptness, accuracy, and scientific knowledge.

In reference to laboratory work, the speaker had followed much the same practice as that outlined in this discussion, except that he refused to assign additional work to the man who had not his previous reports completed. If a man's reports are not completed, so that they may be examined, he is simply refused additional work, and the result is that at the end of the term he has done but a small amount of work, has no credit, and the matter naturally takes care of itself by throwing the responsibility upon the man.

THE PRESENT STATUS AND TENDENCIES OF ENGINEERING EDUCATION IN THE UNITED STATES.

BY ROBERT FLETCHER,

Director of the Thayer School of Engineering.

Engineering education in the United States has reached its present status by a development which to the younger teachers and graduates may appear natural and ordinary; to those who can look back 25 to 30 years, the results are surprising if not, indeed, bewildering.

In order to appreciate the present a glance backward is necessary, even at the risk of repetition of well-worn facts. In 1866 the engineering schools of any note numbered six, with 300 graduates counted during 30 years preceding. The next decade showed a total of about 45 schools with 1,605 graduates counted from 1860; of these 79 per cent. were rated as civil, 11 per cent. as mechanical 10 per cent. as mining engineers. At that time occurred the famous joint discussion by the civil and mining engineers, in Philadelphia, of which the theme was "The Inadequate Union of Engineering Science and Art." We recall this now to show the general attitude of the profession toward the schools only twenty-four years ago. It was then generally admitted that engineering instruction was devoted chiefly to abstract principles; that it was to a large extent separated from the phenomena and conditions of practice; that it was, therefore, ineffective and in disfavor by the great body of practicians; that the spheres of the investigators, school men and men of engineering affairs were too wide apart, and their labors not correlated; that the young graduate was nearly useless even as a conservator; and that he must be made more available by a better adaptation of means to ends.

Whether any points of this indictment still remain, may be an open question, but we are sure that to-day the general relation between schools and practicians is one of accord and coöperation. And not only so, for we know that the high honor and consideration which the leading schools of engineering now enjoy is the necessary outcome of the always faithful and often distinguished labors of the members of this Society, individually, and, since 1893, of the influence and work of the society in its corporate capacity.

Sixteen years later than the time just referred to, *i. e.*, in 1892, the situation was carefully viewed by the editor of one of our leading engineering journals, as to the history, aims, methods and accomplishment of fifty-two engineering schools or colleges.* Then the total of graduate engineers had become more than 9,000, including about 5,400 civil engineers from 45 colleges, 2,800 mechanical engineers from 33 colleges, and 890 mining engineers from 15 colleges; also about 200 electrical engineers (counted under head of mechanical) from 20 colleges. The differentiation of mining, mechanical and electrical engineers began respectively in 1867, 1870 and 1885.

---

* *Engineering News*, Vol. XXVII., p. 277 to Vol. XXIX., p. 138. The editor recognized 94 as giving some instruction in engineering, but of these 42 were either too recent or sent scant information or did not sufficiently separate the engineering courses.

Four years ago the Committee of this Society on entrance requirements recognized 110 colleges or schools of engineering of all grades, but, for lack of responses or other reasons, were obliged to limit their analysis and report chiefly to 89 institutions.

This great multiplication of engineering colleges, and consequent increase of graduates, makes prominent the old question as to an overcrowded profession. If Telford's complaint that the profession was overcrowded in 1830 was reasonable, when the only allowable engineering schools in the English-speaking world, probably, were the U. S. Military Academy and the infant institute at Troy, what then is the presumable situation to-day? The writer has recently procured a limited consensus of opinion upon this point, and others to be treated later.*

To the question: Does the present supply of young graduates or other novices now exceed the demand? 60 per cent. of the respondents replied NO, decidedly; 11 per cent. replied no, as to capable men, especially draughtsmen; 20 per cent. replied yes, adding that many go into other pursuits; 9 per cent. were doubtful or non-committal. The President of one of our oldest universities has recently testified that the demand at present for graduates from its engineering and other technical courses has quite exceeded the numbers available, and similar testimony comes from other institutions. It is generally conceded that during the dull times of two or more years ago, there was a decided surplus of graduates.

---

* Inquiries were addressed to 63 engineers and educators, of whom 74 per cent. responded. Of these 43 per cent. are among American engineers of the highest standing, 20 per cent. are leading professors in engineering colleges, and 37 per cent. are graduates of 5 to 25 years' standing from a single institution, and both teachers and practicians.

Again, on the matter of surplusage, the respondents to the writer's inquiries bear testimony as follows: The question was, in effect: "Is the annual influx of young graduates viewed by the older practicians as an unwelcome intrusion upon a field already overcrowded? Is the demand for and the compensation of experienced men thereby unfavorably affected?" About 75 per cent. held that they are not considered as unwelcome intruders; that they do not seriously affect the business of the older men, most of whom prefer to employ graduates; and that incompetent graduates are numerous, but not more so than in other professions. About 20 per cent. held that the increased numbers lessen the pay in the lower ranks and that the profession is injured by mediocre and "half baked" graduates. About 12 per cent. cordially welcome competent graduates; 4 per cent. held that the business of older engineers is decidedly interfered with by the constant influxes; also that the extension of the schools *has made it impossible for untrained men to enter the profession;* a few made reference to the improved general conditions brought about by the schools, which they do not hold responsible for want of aptitude and incompetency of some young men.

In 1892, the investigators previously referred to found that out of more than 3,500 graduates of engineering colleges, 59 per cent. were in strictly engineering pursuits; 7 per cent. were railway officials, 6.6

per cent. managers of works; 2 per cent. contractors; and above 25 per cent. in other occupations. Recently the writer has analyzed the graduate lists of 27 engineering colleges and schools of various grades, for twelve years, from 1888 to 1899, inclusive. Out of a total of more than 6,000, the percentages of civil, mechanical and mining engineers are respectively 29, 28, and 6, with 3.5 per cent. instructors in engineering; in strictly engineering pursuits, therefore, including steel industry, about 66.5 per cent.; administrative and executive, about 9 per cent.; architecture, 2.5 per cent.; scientific work and other professions, including teachers, 11 per cent.; other business and not classified, 11 per cent.* The returns are insufficient for a wide deduction, but point to the conclusion that about 75 per cent. of the graduates have either adhered to strictly engineering pursuits, or have gone into those having close relation to such occupations. The same general result is true also of the graduates of the institution with which the writer is best acquainted.

The pertinence of these facts lies in the consideration that the college or school of engineering is amenable to the law of demand and supply. While it is the function of the college and university in their general capacity to maintain and raise the standards, and to enlarge ideals so as to stimulate demand for more and better education, it is evident that the engineering college in particular cannot create or control the demands and opportunities of practice. The former should prepare for every kind of specialized work, the latter is concerned with doing such work as wisely and effectively as possible. In order to test the sentiment among the representative practicians before referred to, specific inquiry was made for an estimation of the professional value of young graduates and for frank criticism of engineering colleges. About 17.5 per cent. of the respondents have a high opinion of the graduate, finding him generally well adapted to his work. About 63 per cent. have a low opinion, with modifying statements, such as: he is fitted to begin; has much to learn, especially about the simplest practical points; knows too little and that not well; some picked graduates improve rapidly; granted that he has much useful knowledge and training, he needs to restrain his knowledge until it is wanted. The remaining 19.5 per cent. were doubtful or non-committal.

---

* These figures are only approximate because some of the returns were incomplete, and the most recent graduates are classed according to the intended rather than the finally settled pursuit.

Again, in the criticism of the schools, out of a great variety of views, there was a general consensus of 70 per cent. on the following points: do more work on the fundamental subjects; teach thoroughly controlling principles which every engineer must fall back upon; develop practical sense and train the judgment, and attend only to such details as are essential; avoid side issues. As to the differentiation of courses, or specializing, about 22 per cent. think that the policy is radically wrong; that the tendency is to teach a trade rather than a profession. About 33 per cent. give qualified approval, some in case an additional year could be had for exclusive attention to a selected branch, others in case an election of special branches were confined to the senior year of the present course. About 13 per cent. declared that the engineering colleges generally are undertaking too much; that there is too much stuffing with facts and details and not enough thorough work on elementary and basal principles. Some scattering comments are to the effect that graduates should generally be much better draughtsmen, with far more skill to meet immediate demands; that there is great lack of literary training shown in the inability of many graduates to write a proper business letter and to observe the most ordinary forms and procedure of business transactions; that there is lack of completeness and mastery, even of those things which the graduate professes to know, such as ability to make a neat and adequate set of notes, proper facility in some of the simplest field routine, etc.

If this judgment is somewhat hypercritical, yet it is a composite or resultant from active practicians widely scattered and well qualified to speak, and may not be ignored in an estimate of the present status of engineering colleges. Indeed, the ideals, aims and methods most authoritatively set forth in the Proceedings of this Society are in general accord with the criticisms. Howbeit there is considerable diversity of views not easy to reconcile; for, individually, we are dealing with various and diverse conditions; many are so hampered that they cannot do what they would, and are sometimes forced to do what they would not; it is difficult to get at sufficient facts for correct generalization, and much depends upon the point of view. In what follows, the writer ventures to offer a few suggestions and comments as to present conditions and apparent tendencies.

1. As to the very remarkable development of labor-

atories and laboratory equipment: we are agreed that the value of this agency cannot be overestimated; we are not so well agreed that in the application it may be and is overdone. We may quite generally assent to the statement that the legitimate use of the laboratory for instruction only must restrict it to the illustration and verification of essential principles; but it is evident that there is marked divergence of views as to just what is such legitimate use. The recent establishment of some plants on a very large or full working scale for hydraulic operations, tests of locomotives, etc., has called attention widely to the matter of research work in some leading engineering colleges. Such facilities are useful to experts, but usually require trained helpers in the operation. The writer is not alone in the opinion that students cannot profitably undertake research work in the laboratory, on their own responsibility, or as aids to an expert, until quite near the end of their course.

2. The move for the higher requirements for admission, the writer believes to have a wrong tendency. The invaluable results of the long-continued and painstaking labors of the Society's committee are widely recognized, as well as the stimulus which their report has given to the needed raising of the standards in certain quarters. But the burden thus put upon the secondary schools by the *maximum* requirements is more than they can properly carry. The legitimate work of the college in higher mathematics, physics and chemistry is thus forced back upon unwilling and usually protesting agencies. This procedure tends to aggravate an evil already notorious, viz., great lack of

thoroughness in our so-called education, from the primary school upwards through all grades. Excess of mere method, misdirected supervision which deprives the teacher of proper exercise of initiative and even of adequate power of government, the scattering of effort upon so many studies that any one is pursued amidst many distractions—these are some of the conditions that already produce much poor material for our high-schools and academies. Hence this modern demand upon them assumes an ideal of complete equipment and efficient teaching which possibly might be realized in rare instances, but in general cannot exist.

3. There is a well-defined tendency in some directions to separate the engineering courses and to raise them to the rank of professional or post-graduate studies. This, indeed, calls for higher requirements of admission, *not to the college proper*, but to the professional school. The writer may be permitted to say that his entire experience in teaching has been along this line. The qualifications of applicants are determined by examination ; no one is received upon certification. Many at first took four years in college to prepare, and then the two years of civil engineering study. This was needless ; the college, after awhile, conformed to the situation by offering the entire preparation in mathematics, physics, chemistry, languages and other culture studies in three years ; the first year of exclusively engineering study and practice is thus made elective and leads to the B.S. degree. The C.E. degree comes at the end of the second year of professional work. But this is not all. The majority now prefer to remain out a year, employed in subor-

dinate places as engineers' assistants, often beginning in the lowest rank; these come back to the last year in the school with a strong appreciation and appetite for their work, and are exceptionally well qualified as graduates.

4. In the proper effort to meet the growing demand for a variety of education is there not a wrong tendency towards complication of the entire scheme? Many believe that the practice of beginning specialization at an early period is a grave mistake. Here concentration and simplification are in order, rather than the extreme expansion which some propose. For instance, why multiply courses and degrees? Civil engineer is a very inclusive term. Mechanical engineer is equally comprehensive, even to the extent of taking in the electrical engineer, for whom a separate degree is hardly needed. The mining engineer is properly a civil engineer with no more special knowledge of machinery than the latter ought to gain. The expert in chemical industries and metallurgy may ask for a distinguishing title, but he deals chiefly with the machinery and processes of production.

It is true that the demand of to-day is for trained specialists; but the school for the specialist should come last. The development of a specialty is a man's life-work. Many of our most distinguished specialists had little or no aid from colleges, except in a broad, fundamental training. Let the engineering college develop the man in all that which is essential to his future activity; but let us beware lest we attempt to anticipate too much for one who is yet a student and whose future cannot be dictated by overdoing along lines too rigidly and narrowly prescribed.

THE PROMOTION OF ENGINEERING EDUCATION.

BY WILLIAM G. RAYMOND,

Professor of Geodesy and Road Engineering, Rensselaer Polytechnic Institute.

The purpose of this paper, or talk, is to inquire as to the proper field of effort for a Society for the Promotion of Engineering Education.

The paper is suggested by the knowledge that has come to the writer of a more or less strong undercurrent of feeling that the society is not filling a long felt want. The paper is rather a family talk than a paper, and is not offered for publication. In an exhaustive discussion of the subject, the list of topics submitted as a synopsis might well be a list of subjects for separate papers, but it is proposed at this time to merely suggest a single thought under each heading, thoughts that may seem axiomatic, with a view to bring out a free discussion of the last topic—What are we going to do about it?—which, stated more formally, is, What is to be the future policy of this society?

I trust that such criticisms as shall appear will not be considered personal or intended to belittle the work of any individual who has presented papers before the society, or any committee that has made reports. We all know that the papers and reports have been good and suggestive, but in these days of centralization I am tempted to ask—or: Is this the best way? Is it worth what it costs?

1. The "Engineer" *vs.* the "Civil," "Electrical," "Mechanical," or "Mining" engineer.

We all know that the term Civil Engineer is used to distinguish the engineer in civil life from the engineer in military life, but it is not altogether clear how the terms distinguishing the engineers who deal particularly with steam engines and machinery, from those who are more particularly engaged with electrical machines and conductors came about. It is clear that there is good reason for the titles Military Engineer and Civil Engineer, but it is to be hoped that the engineer who designs and builds great engines, generators, and machines, is neither simply mechanical nor electrical. But this is mere play with words. My thought on this topic is this: There has been too much differentiation in the engineering training in the schools, among courses that require essentially the same fundamental principles of physical law, which fundamental principles are enough to fill the usual four years' course in college; that the engineer is a different sort of fellow from the surveyor, the electrician, the machinist, the miner, the computer, or the draftsman; that he is all of these, and in addition is the organizer and controller of men and great works; that no school ever made an engineer, and the best it can do is to give him some of the tools with which he is to work; that, in short, the engineer is a greater man than the civil engineer, or the so-called electrical, mechanical, or mining engineer; that the work of the Engineering school should be arranged to furnish engineers with the fundamental principles and methods of applied science with which they must work, and that the degree given should express the idea that the graduate is a master of applied science.

2. This thought naturally suggests the second topic, "The desirable requirements for the graduate engineer." These have been so well stated by Professor Burr, in what seems to me to be one of the most valuable papers ever presented to the society, that I hardly dare attempt to improve on his statement. In substance Professor Burr said that the desirable requirements for a graduate engineer are three: A broad, liberal education in philosophy and arts; a thorough training in what may be termed the natural philosophy of engineering, which embraces all that body of mathematical and scientific knowledge constituting the pure theory of engineering operations; only so much crafts-skill as is necessary to thoroughly acquaint him with methods. These requirements were stated by Professor Burr to be the requirements of an ideal engineering course of training, and for the graduate engineer there should be added the evidence of some ability to use the knowledge obtained in designing engineering works.

These requirements are to enable the graduate engineer to meet and lead men, and to solve in the best and most economical way the problems involved in the planning and execution of great works; they are to train the man to think first and then to do, to originate rather than to follow precedent, to design from principle rather than from experience, to know when all the elements of a problem are investigated and that the conclusion is correct.

3. On this second point probably all of us will unite. On the next, the necessary requirements for the graduate engineer, probably no two of us will agree. My own thought is that all of the desirable requirements, that are at the same time practicable, are necessary.

4. So, as to the just and practicable requirements, agreement can hardly be expected. Persons imbued with the commercial spirit will narrow the requirements to those which will enable the graduate, if he has brains, to follow without serious error the ordinary routine of engineering detail. Others with loftier, if less practical, ideas will insist that nothing less than the desirable requirements are just and practicable. I am inclined to the second view rather than the first, but this position needs explanation. It must be remembered that the porcine ear is not converted into the silken purse; but between these two extremes there are many grades of fabric. Provision must be made for training both the large heads and the little ones, as well as those of medium size, to the end that each may fill the largest space in the world that it is possible for it to fill. But the graduate engineer, placing after his name the certificate that he is a master of applied science, with the ability to design, should be one who has pursued to the end the course which the wisest of practicing engineers and teachers, acting in concert, shall have determined to be desirable, necessary and just.

5. The value of a degree is simply that of a letter of introduction, certifying to whom it may concern that

its bearer has done certain things which should make him competent to do certain other things, and like a letter of introduction the value of a degree depends on who gives it. The reputation of the school that lends value to the degree depends on the work of the men that have gone out from its halls, on their ability to think straight and do right. The ability of the graduate to think straight and do right depends on three things, his own native mental equipment, the extent of course and the teaching method of the school, and the personal influence of the men composing its faculty. The degrees of no two schools will ever be valued exactly alike, even though the curriculums seem to be identical. The feeling abroad concerning American degrees is skeptical; the schools of Europe are uncertain as to what our many degrees from our many schools of all grades really mean. Should they not at least stand for a certain minimum of instruction offered and knowledge acquired? and should not this minimum be standard throughout the country?

6. This question suggests the next topic. Should we not turn our attention to graduation requirements, to the determination of a certain standard minimum requirement for an engineering degree, as a matter of much more importance than a standard entrance requirement? What difference does it make where the boy begins? If one school prefers to begin with him in the kindergarten grade, what of it? There is perhaps this of it: If the college course is to be just four years, there must be some pretty definite beginning point in order to cover, in the limited time, the minimum requisite for graduation, and so there may be

some little warrant for a classification of schools on an entrance basis. It is the practice of engineers to build from the bottom up, but to design from the top down. The requirements of the superstructure are first determined, and the superstructure designed, after which the foundation that is to support the superstructure may be planned. So it seems to me that this society may, with some profit turn its attention to the determination of a standard graduation requirement for engineering degrees, which requirement it may advise, leaving each school to adopt this, or less or more, as it may deem best, and to determine the point at which it shall begin with the boy, and the time it shall take to teach him from the beginning to the end. The deliberate advice of this society would have much weight, and all schools would hasten to reach at least the minimum requirement, lest any one should come to be classed in the second rank.

7. It was intended to point out under the head of Theory *vs.* Practice the danger of too much attention to construction details at the expense of broad training in fundamental principles, which it is desired to advance is the special province of the school. But perhaps enough has been said under the topic "Desirable Requirements for the Graduate Engineer" to suggest the position taken in this matter. It must not be lost sight of that the function of the engineering school is to teach the fundamental principles of the great profession of engineering, and that it is not to teach the details of any trade even though some engineering principles may be necessary to the practice of the trade.

8. Now what have we done about it all? Omitting the first assembly as a section of the Engineering Congress of the World's Fair, we have accumulated through a very able committee, a considerable amount of information about entrance requirements to scientific courses in American colleges; we have read and printed some 172 papers and reports, covering some 2,000 printed pages. These papers have treated for the most part the minor details of teaching work, have been of considerable interest and some of them very valuable in suggestion. We have assembled seven times, with an average attendance perhaps of some fifty people, and have talked and exchanged opinions and become acquainted; and we have spent for it all, including railroad fares and hotel bills probably something like $12,000; $6.00 a page for our printed papers, with our pleasant intercourse thrown in. Has it paid? Almost every one of us is, or ought to be, a member of some of the great scientific societies, the scope of any one of which is ample to cover the detail of our work; and almost all of us read, or should read, two or three or more technical journals whose columns are always open to anything of sufficient interest to their readers to warrant publication. Have we not been dissipating our energies at the expense of the greater societies? Is there not a tendency to spread ourselves out too thin? Have we not lost sight of the great aim of all education in the consideration of less important details? Have we not worked with a smaller and less definite purpose than we should? Is not this a reasonably fair statement of what we have done about it?

9. What can we do about it? I suggest that we can appoint a committee to confer with prominent teachers and successful engineers as to what an engineering degree should mean, and what that degree should be; that the committee then formulate a report, taking one or two years as may be necessary; that we again come together to receive and discuss the report and make some general recommendations; and that we should then adjourn sine die with the understanding that when in later years a similar convocation seems to be warranted it may be held. Is not this about all we can accomplish that is really worth the effort we are now making?

It may well be said that any who are not satisfied with the results of our work may quietly withdraw without publishing their grievances as has been done in this paper. To this I may reply that I had this very thing in mind, until I learned that there is a strong feeling of this kind on the part of others, which if allowed to grow means a gradual dying out of the society. It occurred to me that it is better to find out just how strong this feeling is, to discuss fairly the future of the society, and to provide for a more active continuance, or a dignified death, rather than to permit a gradual death by slow torture.

10. And this brings me to my last topic, which I shall leave wholly to you for discussion. What are we going to do about it? Shall we have a definite purpose for the future? Or are we doing now the best we can, and is that best worth what it costs?

Discussion.

(Covering both of the preceding papers.)

President Mees called attention to the fact that in the discussion of both of these papers there is a little conflict. He believed that Professor Raymond sets forth that the object should be to develop the man, the engineer, and not a specialist. In view of these great and good societies which have been generally breaking out—the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Chemical Society, etc., the speaker submitted the question whether the organization of such societies tends to bring together men working in different specialties in order that the engineer should have a common education. Is there any Association that brings together men who are working in different specialties? If a man desires to become a full-fledged member in any of these societies he must give evidence that he is a specialist, or else he may be an honorary member, or an associate member. Now if engineering education is to be promoted, and it is made what Professor Raymond has said it should be, then there ought to be one association, consisting of mechanical engineers, electrical engineers and civil engineers, etc. Now, what is that Association? There was an attempt to have it in the American Association for the Advancement of Science. Practically, you know what the result has been. That is rapidly becoming a congress of affiliated societies; and it is to be feared that the engineers of to-day are still afflicted by the general tendency to specialize in their own work. A little of this broadening element is very useful. The speaker believed that it was especially the function of this society to bring together men who are interested in the purpose and science of engineering. That seems to be the principal justification for this society. If an attempt is to be made to put this thing into dollars and cents, perhaps the labor of the officers and those who prepare papers may bring it reasonably high, but he thought that the expense in dollars and cents cannot in any way measure the effect which this will have upon engineering education and upon the education of engineers. If one comes in contact with other men and schools he carries away with him a small capital which brings a very high rate of interest. If one finds that somebody else here is doing something in a better way than he has been doing it, he wants to copy it, and that will go out with interest with the product which is turned out. The speaker thought that the tendency of the society is to broaden the engineer and make him what it several times has found he should be. Of course, when it comes to constructive engineering, it is a little different. As this association grows older, it will be found, undoubtedly, that a good many topics of burning interest have been fully discussed and no one cares for them after a while. That is the experience in everything of this kind.

Professor Tyler expressed the opinion that the questions raised were entitled to very careful consideration and discussion on the part of the society. If there were any possible doubt as to its vitality, he believes the paper should be seen by all members of the society. He also thought it was true that a great many of the subjects which have taken up the society's time and attention, involving the expenditure of many dollars, have not been of absorbing interest or of the highest importance.

As to the requirements for admission and for graduation, the former may seem, in comparison, insignificant, but the speaker thought there was an advantage in dealing with such questions, and particularly in the possibility of reaching definite conclusions. The question of what the requirements should be for the degree he regarded as so large a one that a committee might struggle with it for ten or twenty years without reaching any satisfactory conclusion.

As to the entrance requirements, it is of practical importance to know what a college requires for admission, because that requirement determines in a measure the extent and subject-matter of secondary education. Four years is the standard duration of the college course, and the level which can be reached in four years of work depends necessarily upon the level previously reached in the secondary school. As to urging the elevation of the standard of admission to engineering colleges, that has not been the purpose of the committee, as will be seen by reference to its reports, particularly that of 1896.

The speaker expressed his appreciation of the importance of the questions Professor Raymond has asked, and added that it seemed to be eminently time to ask these questions as to the past and as to the future.

Professor Woodward said he was rather glad to hear from the last paper, particularly, because it presents the other side. Generally the objection to their mode of presentation is that they are too nearly unilateral. A paper like Professor Raymond's throws a brickbat at our heads. At the same time he has, perhaps for the purposes of argument, underestimated the value of the work of the society. In looking over the history of engineering in the country, one will strike close to the work of this society. It seemed to the speaker that this society had done more than all others to bring something like a clear comprehension of what engineering education should be, and what it really is, in this country; so that if the society had done no more than to publish its volumes, it seems that the members might well consider that they had gotten off cheap at $1.10 per page.

There are two points raised by the papers that seem to be of special importance, and that have been somewhat overlooked of recent years. The first is that raised by Professor Fletcher as to the tendency to depart from fundamental principles. There is the strong weakness in Engineering education at the present time. The number of subjects has been so increased, and the area so extended that the fundamental subjects have been narrowed by the additional matter. It seems that there is too much that is merely illustrative, or practical, like shop-work, to the detriment of what is more important. It has been said that there are two matters of special importance to the Engineer: one is adequate training in mathematics; second, adequate training in mechanics. If a man is equipped properly in these he will make an engineer of himself, but if he does not have these, no amount of other instruction will make an engineer of him.

The other point is the one raised by Professor Raymond with regard to graduation requirements. Attention should be concentrated upon that rather than upon entrance requirements. The speaker explained that he had to look into this general question from a somewhat different aspect; namely, the entrance requirements of their graduate school at Columbia. At first they would not let any one in if he had had training in science exclusively. The notion was held that such a man should not become an M.A., or a Ph.D. But it was finally concluded to be better to discard that idea and they have been getting along quite admirably since that was done. They find that the men who are better able to take up the study of advanced physical science are the men from the engineering colleges, and it is rather disappointing to find that in many instances graduates of classical colleges are unable to go on with even the most elementary subjects offered in physical science. The speaker wished that in some way the attention of the abler men in engineering schools could be turned to the possibilities of graduate study and advanced work. Out of a class of eighty or a hundred, they always have at Columbia a dozen or so who are well fitted to take up advanced work, but, unfortunately, they are wanted immediately on graduation in important positions. The conclusion to which they have come with regard to requirements for admission, is that they can without detriment let the bars down pretty low at entrance and protect themselves by making the bars very high at the exit. That, it was thought, should meet the spirit of this question. The need to be so particular with respect to the entrance requirements is not so great as that with regard to the requirements for graduation.

Professor Lanza said that Professor Raymond had emphasized the all-important fact that there are certain fundamentals common to all engineering, and that any proper course of instruction should be so planned as to make the student thorough in these, whatever else is or is not accomplished, and that any course which neglects these fundamentals is not a proper engineering course. This matter is of such vital importance that a disregard of it means failure, and hence it must necessarily be kept constantly in mind by any professor who really wishes to make his course successful. Professor Lanza did not approve, however, of reference of the matter to a committee, believing it to be too large and too fundamental a question for a committee. Also a committee would necessarily specify minimum requirements whereas the engineering school is and must constantly develop. Imagine a committee on this subject having drawn up a statement of requirements thirty years ago, and their report being read to-day in our society. Such a report would be entirely behind the times and hence worthless. He, therefore, deprecated any such attempt at crystallization as would be implied by the appointment of a committee.

Professor Jackson professed to be rather young among the teachers of engineering, but that his experience had led him to believe that while perhaps the professors of civil engineering know what they ought to be doing, the professors of mechanical engineering and electrical engineering are largely feeling their way. He got that idea not only from observation but from many graduates with whom he had come in contact. He had kept in very close touch with the graduates of the electrical engineering department with which he is most intimately connected, and had corresponded with many of the better men, in whose judgment he could have confidence, from time to time, asking them what had been proved to have been the part of the college course which was best and what had been shown to have been of less importance. Perhaps one of the best replies with respect to the necessities of a college course contained this (the young man was a very loyal man towards his college): "The trouble is they" (many graduates) "know nothing about the law of the conservation of energy, and some do not apparently even know that such a law exists." The speaker had been in the habit of telling his students that the heart of their course was mechanics; mathematics, of course, being necessary. Yet the question to be determined is: How far shall the course go beyond the mechanics and teach the theory of chemistry, of electricity, of thermodynamics and of hydraulics, and then how far shall those principles be applied? Now that is a very important problem to mechanical engineers or electrical engineers in college positions who are trying to turn out satisfactory graduates. He thought the society had done much to help, but that it could do a great deal more if it would bring forward such important problems and do whatever is possible toward solving them. The trouble he had found with the society is that the Proceedings are largely filled up with axiomatic propositions or discussions which have only local application. The speaker thought, too, that a society is not likely to be successful unless it has a well-chosen permanent secretary, well paid, and that this society ought to have a permanent secretary who can give a great deal more time to the welfare of the society than is now possible. A committee will not do the necessary work; the President will not do it; a changing Council, getting together once a year, will not do it; and we must depend upon a good, live Secretary, a broad-minded man, receiving such return that it will enable him to give a great deal of attention to the work of the society.

Dean Alderson expressed much interest in this discussion. He had been wondering whether this was a society for the promotion, or for the prevention, of engineering education. Some of the remarks in Professor Raymond's paper and in the discussion of it had given him harrowing thoughts, but his ultimate conclusion was that at bottom this is a society for the Promotion of Engineering Education: however, there were some things to be said on the other side. He believed that the day when a college was made by having Mark Hopkins on one end of a log and a student on the other was past: that to-day it is necessary to have the best personality that money can buy; that the engineering students, which according to his thought formed the best class of students that come to the college, deserve the finest equipment there is in the market, and the hope was expressed that the

Editorial Committee, if it can, would resolve itself into an Expunging Committee, and keep from the proceedings any statement to the effect that pretty good or moderate apparatus would suffice. Such a statement should not get to three classes of men: first, members of the legislature; second, the trustees of our privately endowed institutions; and third, those individuals who are still alive and contributing to engineering education.

The speaker believed that the society is for the promotion of engineering education, and that its greatest work will be done in covering that broad field designated not only as engineering, but as industrial education in its broadest sense. Those who have had an opportunity to look into this matter probably know full well that to-day the industrial decadence of England is due to her failure to recognize the proper status of engineering education. They have found that they cannot maintain their industrial supremacy through the medium of night and secondary schools, and that the great progress made by Germany is due to her magnificent system of industrial education. Switzerland's wonderful success is largely due to the fact that she has maintained a complete system of technical education. The speaker felt very strongly that in this country the whole subject should be followed very carefully; that some society should be the main spring in its development, and should call attention all over the country to the prominence of this kind of education and no society is better prepared to do it than this. He believed most thoroughly that the work for this society is to cover that entire field of applied science which seeks the general industrial supremacy of our own country.

Professor Allen recalled the fact that some little emphasis had been laid, both upon the matter of entrance requirements and graduate requirements, and that perhaps the effect had been to temporarily obscure a very important matter, which, on the whole, appealed to him the more strongly; and that is that the work of the engineering college, however far it goes, shall be solid and substantial as far as it goes. He thought this was a far more important matter, and if a great deal of the work of this society has been of a sort that might lead to better results in the way of securing solid work, then the society had not by any means been in vain.

Professor Ayres called attention to the tremendous influence of this society in helping the development and in determining the character of engineering instruction in the technical schools in the outlying districts. Members of the society from the great institutions in the East, who have tremendous advantages, and are so directly in touch with the characteristic development of the country as to feel by instinct, as it were, exactly the right direction to take in their instruction, do not, perhaps, appreciate quite fully the significance of the remark made by President Mees, when he said that he came to this society, and read its papers, and took back with him from this contact with the society suggestions as to lines of improvement in his own institution. The speaker acknowledged the greatest possible assistance in the publications of this society in his efforts to do something useful in his own institution. He thought, also, that the fact of the existence of such a society as this, with a fairly well formulated standard and ideas as regards the place and scope of engineering education at the present time, is of the greatest possible help to the man who is trying to fight against the conservatism which is still manifest in many parts of the country, and to secure that recognition for engineering education in colleges which it has been heretofore quite difficult to get. He believed it would be of the greatest possible importance to education in general if engineering education should be given in the large universities, where a student is brought into contact with all phases of education.

These institutions contain a large number of men, however, who are scholarly, it is true, but narrow, and who throw their influence in the Faculties against the broader and better view of things, and the engineering men need all the encouragement they can get from such a society as this. It is well-known how difficult it frequently is to carry a point which to engineers is perfectly self-evident, in the face of opposition. The speaker remembered being shocked by reading an article by a professor of this great institution where the society is holding its session, in which he held up his hands in horror at the disturbance of his dreams of the glories of the age of Pericles by smells from the chemical laboratory. The speaker said that while it shocked him it also encouraged him, for he took this article to certain of his colleagues and asked them if they called the author of the article a very broad man, and they replied "No, we repudiate him."

If, in trying to overcome the opposition of men like the one just mentioned, either in the Faculty or the Board of Trustees, the engineering professor can show by the proceedings of the society that his idea is not merely an individual one, but that he has the backing of the ablest technical men in the world, his hands will be greatly strengthened. If this society did nothing else than to strengthen those who are away from the great centers, and who are trying, all over this country, to work out the problems of educating the people to take hold of the country and develop it, it would have fully justified its existence. For us to go out to the gentlemen who are engaged in engineering around New York and say to them: "What do you think an engineer ought to be?" to model our courses to suit their answers, and adjourn sine die; then to wait until we had fallen far behind and go through the whole process over again—this would surely be a distinct mistake. What could have been done to help the cause of sound electrical engineering instruction, for example, by any committee even ten years ago? What can really be done by such committee to-day? What can we get from the practicing engineers who are engaged in a definite work? What more can we get from them than we can get from ourselves? We are on the inside, and they are on the outside. And the fact that their attention is taken up with specific matters in hand prevents them from taking a broad view. It seems to me therefore, that the paper of Professor Raymond, while having a great many good points, would come with a great shock to many members of the society. I must confess that, while reading the Transactions and being a member of some of the special societies, I have always felt that this society had a great place, and rather than see it abolished I should rather see some of the special societies fuse together or die. I think this society has a field second to none in importance.

PROFESSOR JOHNSON expressed the opinion that if this society is not the most profitable association to which any one of the members belongs, it is the business of the members to make it the most profitable. Their whole professional purpose in the world is engineering education. If it is not, they do not belong here; and if their sole purpose is engineering education and the promotion of it, and if this society is the only society in the country for promoting engineering education, then if it is not serving its purpose and is not of more value to them as engineering teachers than any other organization to which they belong, it is their fault and ought to be corrected, and this complaint should not be quoted as a reason for its abandonment. The speaker confessed that to him it has served a very great purpose, and believed that to a very large majority of the members of this society it had likewise served a very great and profitable purpose.

PROFESSOR FLETCHER merely stated that if there is a living germ in the paper it will germinate, but if no vital principle is embodied there will be no fruit.

PROFESSOR RAYMOND answered that Professor Woodward was right. The paper was only intended for the purpose of bringing out discussion; and that if Professor Ayres and others had been shocked, it was just what was intended. The speaker added that it was not intended to show that the society should die, but to inquire what should become of it, and what was its best field of effort; and that if a suggestion which had been made, were adopted, namely, that some discussion of these papers should be had from the entire membership, the discussion should be confined to constructive criticism or discussion, because there was no purpose to destroy, but to build up.

THE RELATIONS OF THE TECHNICAL SCHOOL AND THE MANUFACTURER.

BY WALTER B. SNOW,

Mechanical Engineer.

In so far as the technical school graduates men who are destined to enter the field of manufacture, the school and the manufacturer stand in the relation of producer and consumer. Thus limited in its scope, it is the purpose of this paper to briefly survey only the interdependent relations of these particular parties with a view to pointing out some of the opportunities for mutual helpfulness.

As the producer carefully studies the tastes and needs of the individual consumer, so the technical school may very properly strive to furnish as one of its products, men effectively equipped to meet the specific requirements of the manufacturer. Until it is universally realized that the work of the school must be supplemented by active practice before the well-rounded engineer can be produced, complaints that the technical graduate is not practical, will, however, undoubtedly continue.

Broadening as may be the mental influence of a technical education, it is nevertheless true that along certain lines there is a tendency towards narrowness. The focus is too short and the field of vision is consequently limited. This is particularly evident in the commercial aspects of the average technical course. It is difficult to make the student see beyond the limits of the work in hand and to realize how the threads of commercial life run through the warp and woof of all constructive designs and manufacturing processes. Too frequently he leaves school with the idea that he is to be simply and distinctively an engineer; that he will not have, and probably is averse to having, anything to do with business. As a result he lacks that breadth of view which is necessary if he would wisely gauge the character of his work by the commercial conditions which surround him.

In a few years he awakes to the fact that while there are opportunities for such individuals as himself, the manufacturer is always on the watch for technically trained men possessed of commercial instincts. As a rule the manufacturer can measure the services of such men more directly than those of the mere engineer, and because they are usually more valuable he pays for them accordingly. It is safe to assert that, measured by income, the most successful technical graduates are on the average to be found in close touch with commercial life.

How then shall the school most successfully fulfil the requirements of the market thus provided by the manufacturer? Most assuredly by keeping in close touch with him, by permitting both student and teacher to imbibe more freely of his spirit and methods, and by giving wherever possible a more practical turn to all instruction. A living example is worth many an abstract statement.

Although the facts of pure science and the fundamental principles of applied mechanics may be taught to-day substantially as they were a decade or more ago, the progressive and successful teacher who has to do with matters of practical design can only keep himself abreast of the times by constant revision of lectures, problems and illustrations. No text-book can keep pace with the rapid strides of engineering progress. It is antedated almost as soon as published. Upon the technical press and upon the manufacturer himself the teacher must therefore depend for information as to the latest state of the art in any given line. But complete files of all important technical periodicals, useful as they may be for this particular purpose, cannot surpass in value the manufacturer's catalogues, which are essentially "original sources."

The catalogue file is the elbow companion of every progressive teacher as it is of every working engineer, and its importance has already been emphasized by your discussions of the best methods of its arrangement. But it is only one of the means at the disposal of the teacher to keep himself and his pupils in close and intelligent relationship with the manufacturer.

So far as direct influence upon the student is concerned, the manufactory is in a material sense a larger laboratory in which he may note the practical exemplification of much that he has been taught regarding the mechanic arts and the theory of design and construction. He there sees work carried out on an adequate scale, realizes the conditions which he may himself have to meet, the means employed to overcome them and the ever-present influence of commercial interests upon the character of the design. That school is therefore seriously handicapped which has not within easy access such opportunities for enforcing its teaching. As a rule the manufacturer is willing not only to throw open his plant for visits of inspection but to even provide opportunity and means for carrying on special investigations. Of course it is but common courtesy that in return he should receive a report of the results secured. To this extent he may be more than repaid for either outlay or inconvenience.

When the school has the misfortune to be so located that such opportunities are not available or when it is more desirable to provide for class room work, the manufacturer may still be of material assistance by furnishing descriptive catalogues, drawings, photographs, models or even full size working machines.

Such material becomes almost invaluable in the equipment of the school. Some manufacturer's catalogues, prepared primarily for the education of the public in the employment of given apparatus, may under proper limitations actually serve as text-books. From his extended experience the manufacturer is often the *only* individual fully qualified to write of the principles of design and application of his apparatus. When he does so the information is frequently of inestimable value to the teacher. The catalogue familiarizes the student with trade literature, acquaints him with different designs and teaches him in many instances to discriminate against the florid descriptions and the extravagant claims of some manufacturers.

In the matter of drawings the manufacturer may furnish to the school the most practical examples of good and current design, and may thereby indicate the local practice in preparing shop drawings, numbering pieces and patterns, titling, indexing, etc. Such drawings have a live interest for the student, they breathe the air of activity. When he makes his drawings let the student do as the manufacturer does, let them be numbered, indexed, filed, and in all respects be treated as though they were designed for business.

The walls of most of our technical schools bear evidence to the generosity, or, is it the advertising zeal, of the manufacturer, in furnishing framed photographs of his machines. Commendable as may be the display of these prints, far more value is doubtless to be found in collections of photographs or of lantern slides showing distinctive types of machines with their parts, as accompaniments to sets of working drawings, or of machine tools in operation indicating the actual process of manufacture.

In the increasing effort to present to the student periodic lectures from men of affairs or from specialists in certain lines, the manufacturer may readily cooperate. He will thus be brought into close personal touch with the school and be led to speak of subjects with which none can be more familiar. Lectures like these make bright spots in student days; frequently they give the first glimpse of the great practical life of the world which the walls of the school have a tendency to shut out. Sometimes problems arise in the experience of the manufacturer which he is incapable of solving or which he by no means has the time or equipment to investigate. Many a teacher would welcome their suggestion as a basis for laboratory or thesis work, while the results of their solution would be mutually helpful.

Again, the school if somewhat limited in its equipment may desire to build by student labor and partially as shop-work exercise, some useful machine of acknowledged merit. Its manufacturer may by stretching a point furnish castings and working drawings therefor. But when the school itself turns manufacturer and advertises its product in the technical press as does one of our leading institutions, the limit has certainly been reached in this direction.

The specially designed working model is usually a valuable classroom adjunct, but it is surpassed in most cases by a typical machine, where the limits of size will permit. A small pump or engine for instance with cylinders, valve chests, etc., sectioned to show the interior working, possesses a character which the abstract model lacks. It is suggestive of actual working conditions and may with the aid of the manufacturer serve to exemplify some specific make of machine. In the school shops or laboratories, there is even better opportunity to present to the student living examples of the best modern practice, to acquaint him with their operation, and, if they are carefully selected, to indirectly instill a knowledge as to the most reputable manufacturers.

From all these things the student can imbibe something of the spirit of the manufacturer. They speak of methods, of trials, of profits and losses. They make clear to him why such and such things in his course of study are essential to a full preparation for his future work. Supplemented as they may be by occasional visits or by vacation trips to different establishments, they tend to more effectually develop the student as he should be developed, if he would eventually meet the manufacturer's requirements.

In all of this, the manufacturer is playing a generous although a not entirely disinterested part. As an individual he may do much for the technical school in the way of gifts and concessions in price. But as a manufacturer he has a very proper reason to feel that in return the publicity given to his product will, if it is worthy, eventually redound to his credit with attendant increase in business. In this feeling he is certainly encouraged by the authorities in most schools whenever he is called upon to reduce to the bottom figure his prices for equipment. Both parties are undoubtedly correct in this reasoning for most technical graduates can trace back to school days a certain predisposition towards some particular make of machine, which resulted from the daily impression made by its use in the shop or laboratory, or perhaps from some favorable reference by the instructor. The manufacturer, if far-sighted, may therefore wisely accept such influence on the student as making up the balance of his account and as eventually giving him a generous return on his investment.

And here the question arises as to the extent to which the teacher shall describe and discuss specific machines or methods. Shall he endeavor in every possible way to avoid all reference to any particular make of machine or device? Shall he teach only by the use of line drawings and in abstract terms or shall he favorably place before his students those working drawings or models, those photographs and catalogues which represent the latest practice in the art? Shall he even invite the manufacturer to come and personally explain certain features? Shall he thereby, and as a practical application of his more abstract teaching, lead the student to distinguish the good from the bad in specific designs, and shall he, by pointing out the superior features of certain apparatus, make him familiar by name with the manufacturers of established reputation in their respective lines.

If he follows the latter course he will certainly best succeed in making of his students practical men with increased commercial breadth, for he will bring them into close touch with the problems of their later life and will without extra effort equip them with a general knowledge of men and things mechanical. If he limits to the classroom and to verbal statements his discrimination regarding named products or types of machines, his action is therefore ethically defensible, when viewed in the light of the results.

But it is not in this way alone that the technical school can return to the manufacturer some of the favors which he is called upon to extend. Its greatest and best service is rendered when it presents him with a graduate exactly qualified for his work, who by training realizes the commercial aspect of all engineering problems; one who is not a mere book student but who is possessed of that homely virtue—gumption. Undoubtedly the man with gumption is born, not made, but given a reasonable spark of common sense and it cannot fail to be fanned into flame under the influence of such features of a mechanical engineering course as have here been outlined.

By giving publicity to the results of its investigations in specific lines the school is frequently able to furnish the manufacturer with information of much value in its influence upon his designs. There may even be conditions under which with or without charge, information may be directly furnished regarding technical matters. Its libraries, its periodical literature and its museums can certainly be thrown open for his use under proper conditions, and there are limitations under which its laboratories might be placed at his service.

Opinions will differ greatly on these questions, but perhaps to no greater extent than do existing methods and courses in our technical schools. Certainly it is wise and proper that the character of the relations between school and manufacturer should be frankly recognized if the outcome is to be an increase in the spirit of mutual helpfulness.

DISCUSSION.

PROFESSOR JACKSON remarked that this paper comes from a class of membership which is very limited and should be encouraged; and the paper should not pass without discussion. The last remarks of the paper reminded him of a statement in the very entertaining journal *Life*, which explained the success of the American navy from the fact that it was full of "grit, gumption and gunnery." Success in engineering depends on grit, gumption and science. The difficulty with engineering education, as the manufacturers have been telling the speaker, is that the colleges do not give the gumption, and he thought that was an overwhelming difficulty. The colleges appear to be unable to give the students a proper feeling of responsibility for doing their work up properly, promptly and reliably; and also to develop their executive ability. If the manufacturers could tell how to add a little in this respect to the methods of the colleges it would be to the manufacturer's advantage as well as to that of the graduates.

MINOR CONSIDERATIONS AFFECTING THE ARRANGEMENT OF A COURSE OF STUDY IN CIVIL ENGINEERING.

BY HENRY S. JACOBY,

Professor of Bridge Engineering and Graphics, Cornell University.

It is not the purpose of this paper to discuss the subjects which should be included in the curriculum of a college of civil engineering, but rather to deal with some details which relate to the arrangement of a time schedule and the effect of variations in such a scheme upon both the student and the instructor.

In order that the treatment may be more definite, it will be applied to a concrete case, and as the information regarding courses of study usually published in the registers of colleges is insufficient for the purposes of a comparative study in this respect, it is necessary to confine the treatment to the course with which the writer is most familiar, viz.: that of the College of Civil Engineering of Cornell University.

Table I. gives the number of actual hours per week assigned to: (*a*) lectures and recitations; (*b*) drawing and the related computations; and (*c*) laboratory practice, field work, gymnasium and military drill, while Table II. gives the corresponding distribution in terms of the hours credit given. In general, one hour's credit is given for each actual hour per week devoted to lectures or recitations, and for two and one-half hours of drawing or field work. Table II. is given for two terms to the year, since the University adopted the two-term scheme since this paper was begun.

TABLE I.

ACTUAL HOURS PER WEEK DEVOTED TO DIFFERENT CLASSES OF WORK.

	Lectures and Recitations.	Drawing.	Laboratory practice, Field work, Drill and Gymnasium.
Freshman Year.—Fall	9	12	7.5
Winter	9	12	8.
Spring	11	12	11.5
Average	9.7	12	9.
Sophomore Year.—Fall	13	6	10.5
Winter	13.3	5	10
Spring	14	5	11.5
Average	13.4	5.3	10.7
Junior Year.—Fall	12	5	9
Winter	15.3	6	0
Spring	11	9	15.5
Average	12.8	6.7	8.2
Senior Year.—Fall	9.3	6.5	6
Winter	10	6.5	8.5
Spring	5	6.5	10
Average	8.1	6.5	8.2

TABLE II.

HOURS CREDIT GIVEN TO DIFFERENT CLASSES OF WORK.

	Lectures and Recitations.	Drawing.	Laboratory practice, Field work, Drill and Gymnasium.
Freshman Year.—First Term	9	4	5
Second Term	11	4	5
Sophomore Year.—First Term	13	2	5
Second Term	14	2	4
Junior Year.—First Term	14	1	3
Second Term	11	3	5
Senior Year.—First Term	9	3	3
Second Term	7	3	4

It is generally regarded as desirable to have a combination of lectures or recitations with other kinds of work in order to give variety to the daily and weekly routine in the classrooms as well as to secure a reasonable uniformity in the amount of preparation required for the succeeding day.

Table I. shows that the average time devoted to lectures and recitations is less in the freshman and senior years than in the sophomore and junior years, and that the drawing occupies more time in the freshman year and less in the sophomore than in the junior and senior years. The difference in the drawing for the first two years is greater than is desirable, but the sequence of studies imposed this condition. The transition from the preparatory school to the college, with the corresponding differences in methods of study and of class work suggests some relative reduction in the subjects requiring lesson preparation and an increase in other subjects such as drawing. The total average numbers of hours in the four years are 30.7, 29.4, 27.6 and 22.8. While the number of hours in the classroom is thus steadily reduced it does not imply a reduction in the amount of work, but rather an increase in the previous preparation required. That for the senior year does not include any allowance for thesis for which a credit of three hours is given.

The averages for the different terms for the four years gives 26.4 hours for the fall, 25.9 hours for the winter, and 30.5 hours for the spring. The small reduction in the winter is due to a slight increase in the lectures and recitations, while the considerable increase in the spring is mainly due to the fact that all the surveying, except the railroad surveying in the junior year, occurs in the spring. A part of the increase in hours, however, indicates an increase in work. The average number of hours per week for the entire four years is 27.6.

It has been the aim to have all the lectures and recitations in the morning between the hours of eight and one, and as much of the drawing as possible, the afternoon work being almost entirely restricted to laboratory practice and field work. The increasing tax of modern conditions upon the eyesight of students makes it desirable that some of their lesson preparation should be made by daylight and for this reason the afternoon work should be kept at a minimum and carefully distributed through the week.

The last hour of the morning should, if possible, be devoted to a subject whose demands on the student are less severe than those of the mathematical subjects. When the student is engaged in the astronomical observatory at night he should not be required to attend an eight o'clock recitation the next morning if it can possibly be avoided.

It is true that the number of available instructors or of available rooms will often interfere with the efforts to secure a compact and well-balanced schedule for the student, but the aim to secure such a result ought, however, to be steadily kept in mind when the schedule is arranged, in order to secure these advantages to the students as far as possible.

Table III. gives the number of subjects per week which are included in the curriculum, exclusive of military drill in the freshman and sophomore years and of gymnasium in the freshman year. The daily schedule (not published) indicates that throughout the course the student usually has either three or four subjects per day, while in a few instances the number is only two. The schedule includes a limited amount of work on Saturday, consisting of field work, laboratory practice, or drawing, the last being required on account of the large classes.

TABLE III.

NUMBER OF SUBJECTS PER WEEK.

Year.	First Term.	Second Term.
Freshman	6	6
Sophomore	6	7
Junior	5	6
Senior	7	8

TABLE IV.

FREQUENCY WITH WHICH SUBJECTS ARE GIVEN.

No. of Subjects.	Times per Week for one Term.
5	5
6	4
14	3
17	2
13	1

In Table IV. a subject is counted twice when it extends over two terms. On computing the average for the four years of the number of times per week which a single subject is given it is found to be 2.5. It is observed, therefore, that on the average the same subjects recur on alternate days. The table also shows that only twenty per cent. of the subjects are given more than three times per week.

The most important question which it is the object of this paper to present, is whether it would not be better to have each subject given five times per week until it is completed, to be followed directly by another subject, thus reducing the number of subjects to be carried forward simultaneously by the student to three or four, instead of the numbers shown in Table III. So far as the student is concerned the following advantages may fairly be claimed :

1. Greater concentration in study. The diversity of interests represented by six to eight subjects per week interferes with that concentration of effort which should characterize the student's work and thereby seriously limits the power of each subject to impress upon the mind its individuality and spirit. The advantages of concentration are widely recognized in regard to surveying, many colleges having put this work either into solid Saturdays, or into several weeks near the close of a term, or into a special summer session.

2. Greater interest. This is implied in the preceding statement, the experience of many instructors being that it is very difficult to develop and sustain the student's interest in subjects that are given only once or even twice a week.

3. The work can be more uniformly distributed than is possible with subjects that range in frequency from one to five times per week. On paper such a distribution is always possible, but practically the limitation of classrooms and conflict with one or more hours of the required instructor's time, interfere with such a plan. Under the proposed arrangement there would be less chance for the adoption of a course which first

came to the author's attention some years ago, and which included twelve lectures and recitations, eight hours of drawing, and fifteen hours of laboratory and shop work. Experience proved that the work could not be fairly equalized and at the same time the large number of actual hours made the student so weary physically that it was difficult for him to do justice to the required lesson preparation in the evenings.

4. There is less danger in overloading the students. There is always a tendency on the part of a teacher who is intensely interested in his work and ambitious to secure large results, to increase his requirements, often unconsciously, without due regard to the proportionate demands of other subjects, and the larger the number of subjects which the student deals with in a week the larger will be the aggregate of such excessive requirements.

5. Each student will be thrown more upon his own resources. When a subject occurs only once or twice a week there is a natural tendency in some to put off the lesson study or the writing of a required report and then to depend in greater or lesser degree upon others who made their preparation more promptly. When a subject comes every day it still affords some opportunity in this direction, but the rapid daily progress of the work gives the practice less encouragement. Lecture notes will generally need to be written up at once, and thus the advantages of the early review are secured.

The instructor would also be benefited: 1. By concentrating his energies upon a smaller number of subjects each week, thus permitting either better preparation for the daily exercises or leaving some time available for advanced study and investigation. As the salaries now usually paid to instructors are small as compared with the financial returns in engineering practice it is worth while to make the conditions under which their work is to be done as favorable as possible. 2. By frequently requiring more completely matured plans before a subject is begun. Sometimes when a subject occurs only a few times a week, a temptation exists to arrange some part of the course as the work proceeds which really ought to be made at the start for the best interests of both instructor and student.

Discussion.

Professor Raymond said that the paper brought up a subject on which he had thought considerably. He had had a peculiar opportunity to consider the merits of the question which has been presented. He had studied at two colleges. In one this plan was carried out and in the other it was not. He had taught also under these conditions, and was free to confess that it is decidedly the best plan to take up a subject and continue it until it is finished. It is the policy of the Rensselaer Polytechnic Institute to do that very thing. The Institute has been criticized and the question has been asked, " how can you teach the whole of that subject in so short a time ? " Perhaps not all of it is taught, but the subject is certainly covered in some way, which has thus far seemed to be satisfactory, usually in a less number of recitation hours than are required in most other engineering colleges for the same subject. The courses are peculiarly arranged, and one may think it odd to see a subject put down "2 weeks"; another "3 weeks"; or "5 weeks." This has some disadvantage; before he gets to the review, the student may forget a good deal of a course which occupies two weeks at the beginning of the term. On the other hand, when a course is taken up lasting only two weeks, the advance is dropped at the end of the two weeks. There is rarely a repetition of a day's recitation. If a class is not well prepared, it is the rarest sort of a thing to take up the same topic again next day. It is usually necessary that the student, to get on, shall prepare for recitation every day. The term is divided into three periods: advance, review, and examination. At the end of the entire advance period, nothing but review is taken up, going over somewhat hastily everything that has been done before, getting perhaps more out of the review than the advance. Then comes the period of examination, and nothing but examination goes on. It is found to work very well. There is always a recitation every day in subjects under way at that time, and when one subject is finished another takes its place.

Professor Johnson thought that most of the courses were arranged for the convenience of the teachers, and not for the benefit of the students. He was satisfied that it is greatly to the benefit of the student to concentrate his attention on a few subjects at a time. It is very convenient to keep all the courses running and the teachers uniformly employed so as to distribute all this work evenly over the length of the term. He thought that one of the great benefits which he had derived from this meeting would be the reorganization of the courses of study at the University of Wisconsin.

PROFESSOR MERRIMAN referred to one institution which before beginning its work formulated very carefully a plan of arrangement of studies, namely, the University of Chicago. Two subjects, the major and minor, go on for six weeks, and the speaker was told that the results there are exceedingly satisfactory· While he had not had any experience in this plan, he had seen the inconvenience of the method of giving six or seven subjects per week. He would ask how any one present would like to teach six or seven subjects per week? The student is under the same disadvantage in preparing them. Concentration is necessary, and he thought that about three subjects, at the most, would fill up a student's time in such a way as to give the necessary variety and to secure the best results. On one point he had experience, namely, in connection with surveying, where courses are going on during term time and also in the summer. The summer school courses occupy the student's entire time. In the morning a recitation or lecture is held, then field work, and in the afternoon drawing; the course covering exactly the same ground as the one given during term time. Now, he had observed much difference between those two classes. In term time the men may have other subjects before and after a surveying exercise, and there is sometimes lack of careful attention in the drawing room. In the summer time there is nothing of that sort, but the men attend closely to their work and with greater interest. As far as that experience goes it indicates that the number of subjects per week ought to be reduced.

PROFESSOR HAZEN explained that in the college with which he was connected the subjects are divided so that a student carries at least five subjects, and sometimes more. In civil engineering he carries not more than two and sometimes not more than one. He opposed the college idea of having five or six subjects. He was decidedly of the opinion that the system of carrying not more than two subjects is very much better, and he has asked the question of some of their best young men, and with one accord they have said that they prefer the system of carrying only two subjects at a time. They can concentrate their minds and do better work. He felt confident that they were getting better work under that system.

PROFESSOR A. W. FRENCH stated that at some institutions they do not have to teach a good many subjects in Civil Engineering. His first remedy for that was to do just what has been suggested : to take these courses and provide an examination, if necessary. He has concentrated, and has thereby covered more work than was covered before in the same time. It is utterly impossible to cover five or six subjects in any kind of shape, but something can be done with one or two. Many of our higher institutions have adopted the system giving five or seven subjects per week, but he was glad to hear that opinion was turning the other way.

PROFESSOR JACOBY added the statement that he was anxious to have a late report from the University of

Chicago on this subject, and that he was very fortunate, indeed, in meeting on the train one of the professors of that university, who, in response to his inquiries, assured him that they were delighted with the success of their plan. That with languages, particularly, the professors felt that the students got the real spirit of the language very much better than under methods which are in use in other places. He understood that in most cases the students take one major and two minor subjects, the difference between the two being simply that the major is a longer course. This applies to undergraduate work.

Professor Allen suggested that he was sure that Professor Raymond had convinced the members present that very much had been done for the good of engineering education that does not have to do with requirements for graduation; in relation to methods of teaching, courses, and the like. A great deal of the work going on at these meetings is good.

Professor Raymond remarked that the University of Chicago had received a good deal of credit for this system, but that Amos Eaton in 1824 adopted this scheme at Troy, and it has been going on ever since.

ORIGINAL INVESTIGATIONS BY ENGINEERING SCHOOLS A DUTY TO THE PUBLIC AND TO THE PROFESSION.

BY ANSON MARSTON,

Professor of Civil Engineering, Iowa State College.

The function of the modern university includes much more than the mere imparting of instruction to its students. In a now recognized, important sense, the entire public must be considered university students, and by frequent publications. addressed to different classes of people, by extension lectures and possibly by correspondence instruction, the modern university must seek to educate this greater student body. Besides this no university, no department even of a university, can be considered to be doing living. vital work, unless in addition to its routine of instruction it is carrying on original investigations. Otherwise its work will be merely mechanical. No student can be properly educated without bringing him into such close contact with veiled truth that he feels the very throb of her pulse, and receives direct from her the inspiration to become himself a searcher after truth.

It is the object of this paper to make a plea that the function of the modern technical school should be, in its particular field, closely similar to that of the university, as outlined above. The author believes that in addition to educating engineers the technical school should by special courses, supplying special equipment, train leaders for all the industrial and commercial work of modern civilization. More than this, he believes that, by the publication and distribution of frequent bulletins on technical, industrial and commercial subjects, by its faculty taking part in the meetings and conventions of the various technical, industrial and commercial interests and societies, and eventually perhaps by systematic extension lectures and correspondence courses, the technical school should seek to educate the industrial and commercial public in the applications of science to their work.

It is the special object of this paper, however, to make a plea for systematic original investigation work in technical schools. The necessity for work along this line has been so great and so plainly apparent that a great deal has already been accomplished. The term original investigation should be understood to include much besides experimental research. The writing of good technical books, for example, involves a large amount of original study and research, for such books should never be mere compilations. In the columns of one of our principal technical journals 73 technical books were reviewed during the year 1899, and 25 of these were written by professors in engineering schools. There is not a single technical journal, and perhaps not an important technical society publication in the country to whose columns frequent contributions are not made by engineering educators. The current progress of technical education is sweeping engineering professors farther and farther away from the old exclusive devotion to classroom instruction, and more and more bearing them into active participation in the daily outside work of their professions.

The development of original investigation work at technical schools has been especially rapid in late years along the line of experimental research. The modern methods of instruction require extensive and expensive laboratory equipment, which is also available for experimental research. The multitude of subjects pressingly needing such research is so great that energetic engineering instructors are naturally led into experimental investigations. Frequent reports of the results of such work are seen in the technical press and in technical society proceedings. Also most engineering schools maintain regular publications, in which the results of many experimental investigations by both faculty and undergraduates are reported. It is impossible to mention here many of the numerous important experimental investigations which have been made at American engineering schools, but attention will be called to two cases: first, all are familiar with the important work in connection with paving brick which has been done at the Universities of Ohio and Illinois, and which has been accepted as authoritative by both engineers and manufacturers; second, the great hydraulic laboratory at Cornell has required the most lavish expenditure of money devoted exclusively to preparation for experimental research in a single line of work yet seen at an American technical school.

The great value of such investigations to the engineering profession is readily apparent. The value in connection with the instruction of engineering students is also great. Bringing the student into personal contact with the progress of such investigations, carried on by his instructors, does much to awaken in him professional enthusiasm and an ambition to become himself a contributor in the future to the common stock of technical knowledge. The student is led to see that there is much more to engineering education than the mere absorption of knowledge, and much more to engineering practice than the mere routine of carrying out preëstablished methods. He sees that he must learn to think for himself in his future work, and to investigate for himself the problems which he will encounter. In the simpler work connected with experimental investigations bright, reliable students can often be employed to advantage. This is especially true in work suited to thesis investigations. The author knows of no more valuable training a student can have than to carry out successfully an experimental search for undiscovered truth, overcoming all the unforeseen difficulties sure to be encountered, and at the end completely digesting the results obtained. The author believes, however that all experimental work by undergraduates should be done under very close supervision by a skilled instructor. Much valuable thesis work has been done in this way at engineering schools.

While much has already been accomplished in original investigations at American technical schools, such work has heretofore, with few important exceptions, been carried on spasmodically, with no systematic, prearranged plan. The author believes that this should now be changed, and that, wherever possible technical schools should deliberately plan for investigations as a part of their regular work. Each school should decide what lines of work are best suited to its location and circumstances. Proper space and equipment should be provided. The faculty should be made large enough to permit the necessary time to be devoted to the work. Funds should be provided to meet the expenses. Arrangements should be made for the regular publication of the results.

Investigations which can be carried out at engineering schools are of two kinds: first, those mainly of professional interest and value; and second, investigations whose results have a considerable commercial, industrial, and public, as well as professional value.

As to investigations of the first kind it may be said that the practicing engineer frequently encounters problems which ought to be investigated experimentally, but it is seldom the case that he can command the necessary laboratory equipment or the time for such work, or can induce his employers to furnish the necessary funds. Such problems should be referred to the schools and there investigated. Thus the schools may perform their duty to the profession, and may ask in return, as they do even now, that the practicing expert shall give them the benefit of his experience, in non-resident lecture courses. There will result that coöperation and close association between engineering education and the practicing engineer which is so essential to the best interests of the profession.

As regards investigations at technical schools having a commercial and industrial value, attention may be called to the prominence which has recently been given to discussion of the value of scientific technical training for the leaders and workers in our manufacturing and commercial industries. The mono-technic and the trade schools of Germany have been held up as models for the world. The author believes that, under American conditions, the first decisive step towards solving this problem should be taken at the technical schools, especially the State colleges and State universities which are the beneficiaries of the Morrill government aid laws. The nearest approach now made to systematic technical education for one industry in this country is seen at our agricultural schools and experiment stations. At the best of these schools not only are the students given a thorough scientific education and training for leaders in agricultural work, but also extensive scientific agricultural experiments and investigations are continually being carried on. The results are systematically published and distributed in bulletins. The faculties attend the regular meetings of the institutes and conventions of agricultural interests, and there inform the public concerning the results of the college work and the principles of scientific agriculture. The author believes that similar training and aid should be given by our technical schools to American manufacturing, commercial, and other industrial interests. At least, investigations helpful to these interests should be undertaken, and the results systematically published. The school which will undertake such work will receive hearty support from the industrial interests of the country, and means for carrying on the work will not be lacking.

In a new and rapidly developing country like ours there are many yet untouched resources. It would greatly accelerate the development of these if scientific investigations of their possibilities were made by the technical schools. For example, in the case of quarries, deposits of cement materials and clay deposits, both the raw materials and the finished products can be carefully tested and their qualities published. Again, in the processes of manufacture, the effect of different processes on the quality of the product can be studied. New applications of Botany, Chemistry and Physics to manufacturing processes can be found.

In fact the subjects suitable for investigation at engineering schools are very numerous, and no attempt will be made here to give an exhaustive list. The following may be mentioned:

Theoretical Mechanics.

Experimental studies, accompanied by mathematical investigations of the theory, may be made of such problems as the actual pressure against retaining walls, the theory of concrete and steel combinations, problems in hydraulics, and many others.

Materials of Construction.

The methods of testing the materials of construction need experimental investigation, and should be completely standarized. The properties of both long-used and of new materials may be studied and made known. Standard specifications may be prepared for the properties developed by the standard tests.

Sewage Disposal and Water Supply.

The methods of analysis of sewage and water need careful experimental study to determine the best methods and the interpretations to be placed on the results. Analyses of sewage and water can be made for the municipalities and corporations of the State. Many sewage and water purification problems can be studied experimentally, and systematic examinations and reports can be made of existing plants in the State.

Steam and Electrical Engineering.

Laboratories can be provided for tests of different kinds of machinery, and for the experimental investigation of problems of correct design. Efficiency tests of outside plants can be made.

Mining Engineering.

Geological studies of deposits of building stones, cement materials, clays, fuels, and ores can be made, and the qualities tested.

Manufacturing.

Applications of science to manufacturing and the comparative values of different processes can be studied as already mentioned. With the aid of statistics, political economy as related to manufacturing can be studied.

Transportation.

Good roads and road materials in the State can be studied. Laboratories can be established, fitted for tests of transportation machinery. The political economy of transportation problems can be studied.

The author does not claim that any one school should undertake all of the above lines of work. On the contrary, the work undertaken by any one school should be restricted to what it can carry on for a long period of time, and so extensively and thoroughly that the results shall be conclusive. Particular schools would naturally become authorities in particular lines, and their work would not be duplicated by others, although many lines of work would need to be carried on by several schools because local conditions differ.

As an illustration of a modest and imperfect beginning of such work, made under many difficulties, the author would say that at the school with which he is connected the following lines of work are now under way:

The college has a sewage disposal plant which purifies about 50,000 gallons per day. Regular analyses in connection with this plant are made, complete records are kept and investigations with the plant are under way. Special tests with smaller apparatus are planned. The college has just coöperated with a neighboring city, securing and publishing at the expense of the city, the preliminary data for the design of a purification plant for 2,000,000 gallons of sewage per day. The college proposes to examine and report upon sewage disposal plants as fast as they are installed in the State. In connection with the clay interests of the State, quite a large number of plants have been visited, samples of clay and brick secured for tests, the clays and processes of manufacture studied and several thousand tests are under way. Samples of new clay deposits are frequently received, analyzed, and reported upon. An appropriation has been made for starting a ceramic laboratory, modeled after the one at the Ohio State University. A set of tests of the heating properties of the coals of the State is under way. Tests of the building and paving materials of the State are being made, and extensive statistics of brick paving collected. Special investigations of timely interest are taken up as opportunity permits. It is proposed to extend this work.

It is obvious that if the extension of the work of the modern technical school advocated in this paper should be made to the utmost possible extent the status of the technical school would be greatly changed from what it now is. No longer could the school be considered as existing simply for the benefit of its students. All practicing engineers could equally consider it theirs, and the great industrial and commercial interests of the country would consider it theirs. Such a technical school would be one of the most potent agencies imaginable for the betterment of the welfare of the people, and for the progress of modern civilization.

Discussion.

Professor Gray mentioned his previous remarks on the question of equipment in college laboratories, and that these remarks, together with some others, seemed to have offended a good many members of the society. He had refrained from saying anything as these other remarks were made, because endless discussions are apt to arise; but this seemed to be an appropriate place to get matters straightened out.

First, there is the question of the equipment with regard purely to teaching in the laboratory; second, the question of getting the proper men to do the teaching; and third, the question of the equipment necessary so that the laboratory shall properly fill its place in an educational institution, which is an entirely different thing. The speaker agreed with those who say that we should have the best equipment that can be obtained. He did not, however, believe in every institution having the same thing as a show-piece of apparatus for some particular subject. It is unfortunate if a student should think that such an instrument, costing alone, perhaps, thousands of dollars, is the only thing he can use for that particular kind of experiment, when he might have an instrument worth perhaps a hundred dollars to do the same thing sufficiently well for most practical purposes. If, however, the object is the best results which can be obtained by the original investigation of a subject, the apparatus ought to be of the best kind; but he hoped that the student would not be the man to make that investigation. Undergraduate students are not the men to make valuable researches. He said that he had had occasion to investigate the value of scientific work and to go over the work of a great many investigators; but it must be confessed that the majority of papers on original investigations made by students are not worth reading. The best men are wanted to make the investigations, and people are to be persuaded that that is one of the great objects of such institutions, and that they cannot do better than to spend their money to provide means of doing that work; but let not such work be confused with undergraduate instruction in the same institution. Of course when men are provided who are familiar with their subject, and who are enthusiastic over the subject, much better results will be secured than with men who care little for the place except for the salary. Men are wanted who have a love for their subject and for its advancement. and in order to get such men to come there must be provided a counter attraction. A great many get this attraction through investigation. The manufacturers are alive to the advantages of these investigations. and they make them for their own information. There is a commercial value in that sort of thing. However, the general public does not reap any great advantage from this. Some public way of getting at the truth of things is needed. and one way to do it is through our engineering institutions.

THE PROJECTION LANTERN IN ENGINEERING EDUCATION.

BY C. RUSS RICHARDS,

Professor of Mechanical Engineering, University of Nebraska.

Among the most serious of the perplexities surrounding the work of an instructor in engineering, is the determination of the best methods of presenting to the student those courses of study which deal with the practice of engineering. Less difficulty is experienced with the presentation of the purely theoretical courses, although even these subjects will amount to little unless their applications in practice and their correlation to other work are made perfectly clear and intelligible. The more fully a student becomes familiar with engineering methods and processes as carried out in the business world, the more he has seen of the application of mechanical principles in the construction of actual machines, the more intimately acquainted he is with existing machines, particularly the "type" machines used in the generation and transmission of power and in general manufacturing operations, the more useful will he be to his future employer. Experience must be gained somehow, and the more of practical details that can be crowded into our different courses, the better will they be. Palpable errors of design in existing mechanisms should be impartially pointed out, and the advantages and disadvantages of one machine over another may well be given in many of those courses of study dealing with engineering practice.

In the curriculum of the engineering school there are certain courses of study which require copious illustrations from practice if they are to be made of any lasting value to the student. These subjects would include at least the following courses; the lectures on machinery, shop methods and management, mechanism or kinematics of machinery, machine design in all of its branches, steam machinery, electrical machinery, and power transmission. To a lesser extent, possibly, every other subject should be illustrated as fully as the time will permit. To illustrate: the writer has known the subject of mechanism to be presented from a text-book without any reference to existing applications of the mechanical movements studied. Since the text usually contains only the bare outline of the movement, isolated from all accessory mechanism, it is doubtful whether the student will readily recognize the movement in an actual machine when its salient characteristics are obscured by other parts of the machine. Certain it is that the student is not so readily able to make use of the principles of mechanism when he is unfamiliar with the exact methods of use in existing machinery. And so machine design is sometimes taught as one would teach mathematics, and thus this subject, which is one of the most important in the whole engineering course, is less valuable to the young engineer, because he does not know what is done in practice. We sometimes teach the mathematical theory of the steam engine before the student has a clear conception of what a steam engine is or how it works. If he is made thoroughly familiar with the machine, the theory will more naturally and readily follow. The writer realizes that it is easier to present a subject without such illustrations as have been mentioned, but what is the result? The student learns a thing, but without a clear idea of its relative importance in an engineering way. He will doubtless have to grope awhile before he sees light.

The necessity for the elaborate illustration of a subject may be less in some institutions than in others. In those schools which are favorably situated in the center of a manufacturing community containing innumerable examples of the best in engineering, and whose students are familiar, from contact and observation, with many of the applications of engineering work, the need for classroom illustrations is not so great. But in schools situated in the center of vast agricultural districts, containing relatively few examples of engineering skill, whose students know little if anything of the subjects they are to study, the elaboration of illustration can scarcely be too great. In the former institutions classroom illustrations may be an aid to outside observations, while in the latter they are absolutely essential, since they must serve as classroom illustration and in a large measure take the place of outside observation as well.

The best method of illustrating the various courses in engineering is difficult of determination. It is probable that each member of the society has different ideas on the subject, and that anything like uniformity of illustration does not exist. The writer is obliged to confess that he has not yet reached any entirely satisfactory solution of the problem—in fact is doubtful whether an entirely satisfactory solution can be obtained.

Existing methods of illustrations may be divided in the following groups: 1. Text-book illustrations. 2. Blackboard sketches. 3. The use of trade catalogues, photographs and blue-prints. 4. The use of special charts. 5. The use of prints to be inserted in the student's notebook. 6. The use of the lantern. 7. The use of models. 8. Shop visits. 9. Laboratory work. It is undesirable, if not impossible, to limit one's illustrations to any single group; a judicious combination of methods will naturally yield the most satisfactory results.

Of the schemes employed for the illustration of lectures, the projection lantern possesses a number of advantages over other systems although it must be confessed that for classroom lectures, when used alone, it possesses a number of decided disadvantages.

A large projection on the screen enables the instructor to explain with great minuteness the details of a piece of mechanism to a class of any size. No other system affords so ready a means for demonstrating a principle or its application, because in no other way can the class so easily follow the explanation of the instructor. Blue-prints or trade catalogues distributed to the class answer very well where specific explanations are unnecessary, but it is difficult for the instructor to point out small details in this way. All kinds of tables, diagrams, etc., can be shown on the screen, saving the necessity of expensive charts, or the labor of placing the matter on the blackboard. The student enjoys such illustrations, because the subject, being of larger size, appeals more to him than a sketch or a small cut—it seems more real. Then, too, there is to most of us a fascination about the lantern which fixes and holds our attention to the subject.

The writer does not advocate "lantern shows," where a large number of slides of small value are shown merely to make lectures popular, although with certain subjects it is desirable to show a good many comparatively unimportant details to enable the student to more fully appreciate the importance of the subject as a whole. Again, in institutions which are remote from engineering works of importance. fully illustrated lectures may in part take the place of actual shop visits. The late President Smart of Purdue University, in describing a set of several hundred slides they had made for the University, illustrating the building of a locomotive, pointed out to the writer that in a couple of hours one could learn more of the building of such a machine than would be possible by a casual inspection of the locomotive shops. The work that had required a photographer some months to reproduce could not be seen in much less time by actual inspection. The same thing is true of every line of engineering work. The use of the lantern enables the increment of time between the completion of important details of the work to be reduced from weeks to minutes, and in a few hours the student may see in succession the results of the work of years.

Although otherwise so well adapted for the illustration of technical subjects. there are three rather serious disadvantages attending the use of the lantern in the lecture room: 1. The necessity of darkening the room prevents the taking of adequate notes. 2. Where a considerable number of slides are shown, it is difficult to remember all of them. 3. Unless there be some quick means for darkening the room and unless the light for the lantern is always ready to be used, it becomes necessary to prepare specifically for an illustrated lecture. The above difficulties may be wholly or partly overcome, however, by showing but a few characteristic slides during the course of a lecture, necessitating the darkening of the room for but a few minutes, and by distributing prints from the negatives used in preparing the slides for further study and for insertion in the notebook. Such negatives and the lantern slides as well, may be almost as readily filed for reference as the cards in a card index.

The writer has had some difficulty in securing suitable material for slides, but has found that usually the best results may be obtained from the use of cuts or heavy line drawings. Photographs ordinarily lack sufficient detail for the production of technical slides. To secure the best results from the use of the lantern, the collection of slides should be kept up to current practice, although this is not an easy thing to do. The writer has given the matter considerable thought and wishes to present to the society a scheme which will do much to solve this problem if it can finally become established.

The more progressive manufacturers of machinery are extensive advertisers, and annually spend large sums of money in bringing their products before the engineering public. Most manufacturers realize the importance of engineering schools and are glad to donate quantities of their catalogues for distribution among the students, many of them are willing to supply sets of blue-prints for class reference, and some of them will supply sectional models to more fully illustrate the action of their apparatus. These things are all of material assistance to the work of instruction in the technical school, but the writer would suggest an additional form of advertising among the technical schools, namely, by lantern slides. A small set of slides, illustrating the important details of the machines built by a given firm could be prepared at a nominal cost to the manufacturer. There are probably fifty or more technical schools in this country which would make good use of such slides, and the cost of that number of sets of slides would not be great. As new machines were brought forth, the manufacturer could have prepared additional slides illustrating the same, at the same time that he issues circulars describing the new appliance. These slides would thus become for the manufacturer a sort of permanent advertisement which would be used in the technical school from year to year, until the old machines shown by the slides were superseded by later devices for accomplishing the same work, although even then the old slides would possess a certain historical value that would be of some importance in engineering education. There can be but little doubt of the value of such a scheme to the technical school, and the writer is firmly convinced that from a business standpoint alone, the manufacturer would find the plan a valuable one.

During the past winter letters setting forth the above plan were sent to a few of the leading concerns in this country, and the replies were, on the whole, favorable to the scheme. It was pronounced a novelty, and several firms felt that it would be worth trying when they next had a photographer at their works. Some concerted action by the members of the society might result in a trial of the plan by the manufacturers of this country. The whole scheme involves the question of the relations of the technical school and the manufacturer. It would seem to the writer that in many ways the two might more fully coöperate, to their mutual advantage.

The writer has not attempted to discuss the other phases of the subject of the illustration of engineering courses, although he realizes that the other methods mentioned may all be used to advantage. He would particularly urge that text-books be more fully and carefully illustrated, even to the extent that some persons might characterize them as "padded." Catalogues, photographs, blue-prints and models are of the greatest value, and they must be given a prominent place in any general system of illustration. The modern trade catalogue is necessarily more up-to-date than the text-book, and in consequence it can be made a most useful adjunct to the work of instruction.

The whole subject of the use of illustration in engineering education is so important that the writer hopes the question may be further discussed in its different phases.

DISCUSSION.

PROFESSOR CALDWELL (by letter) stated that, both as a student and a teacher, he had felt that the transitory character of the lantern views was a serious disadvantage. The impression left upon the mind often seemed to be little more permanent than upon the canvas. In his recent use of the lantern he had supplemented it with blue-prints taken from the positives of the slides and distributed to the students to be enclosed with their notes.

THE DEVELOPMENT AND PRESENT STATUS OF ARCHITECTURAL EDUCATION.

BY JAMES M. WHITE,
Associate Professor of Architecture, University of Illinois.

The earlier architectural schools and all of the later ones, with two exceptions, were originally affiliated with engineering colleges from which they have gradually been growing away by eliminating the engineering branches which formed so large a part of the original courses, and adding technical architectural subjects as fast as increased teaching force became available.

The greater facilities for foreign travel, the explorations by archeological societies, and the perfection of photography have so increased the material available to the architectural instructor that this separation of courses has become necessary.

The engineering schools have in the mean time materially changed their courses, but the change or growth has been comparatively uniform and there is to-day in our universities a recognized standard for each of the several engineering courses.

For the education of the architect there is not so well established a curriculum, and there is great dissimilarity in the courses now offered. Some have been formed to compete with the Ecole des Beaux Arts at Paris, some to give the man the greatest possible earning capacity immediately upon graduation, while others have laid great stress upon general education. These various courses have met with about equal patronage but the schools have not established themselves as firmly in their relation to the profession as have the engineering colleges. The sympathy and coöperation which should exist between the practitioners and the schools are almost entirely lacking outside of the ranks of the architectural graduates. Draughtsmen who begin their education in offices are rarely counseled to seek elsewhere for its completion, and when under this influence it is difficult for the schools to get hold of them.

To determine the extent of the training of the men now entering practice in Illinois, table I. has been compiled from the applications for licenses filed with the Secretary of the State Board of Examiners. Ninety-five had been granted licenses prior to June 1st, and the extent of their education is shown by column 1. Twenty-two of these were established architects practicing in other States and twenty-two more were within the State but above thirty-five years of age. If these two classes are eliminated the remaining fifty-one will fairly represent the generation of architects now entering practice, and their preparation is shown in column 2.

Of these, 37 per cent. are graduates of architectural schools and 33⅓ per cent. have pursued partial or special courses in architectural or art schools from one to two years. Ten per cent. are C. E. and M. E. graduates and nearly 18 per cent. have been schooled in offices only.

TABLE I.

	Col. 1.	Col. 2.
Graduates from American Arch. Schools	19	16
Undergraduates from American Arch. Schools (av. time of attendance 2.43 years)	7	5
Special students in American Arch. and Art Schools (av. time of attendance 1.35 years)	10	8
Graduates from the Ecole des Beaux Arts	1	1
Undergraduates from the Ecole des Beaux Arts (av. time of attendance 2 years)	2	1
Graduates from Continental Tech. and Bldg. Schools	7	2
Undergraduates from Continental Tech. and Bldg. Schools (av. time of attendance 2.14 years)	11	3
Undergraduates from English Arch. Schools (av. time of attendance 1.5 years)	2	
Graduates from American Engineering Schools	6	5
Graduates from Manual Training Schools	1	1
Partial Collegiate Course	5	1
High School	15	7
Common School	9	1
Total	95	51

ARCHITECTURAL SCHOOLS OF THE UNITED STATES.

Table II., comparing the architectural schools of the United States is self-explanatory and the institutions are so well known that descriptions are unnecessary. In addition to these there are a few institutions offering a two-year course only, which are not considered to belong in the same class. The entrance requirements are based on the classifications given in Vol. IV. of the Proceedings of this Society, and are quite uniformly high. The regular course is in all cases four years and leads in ten of the thirteen institutions to the B. S. degree.

Harvard gives both the A. B. and B. S. degrees to graduates of the architectural course, who have previously taken three years' work towards the A. B. degree.

The decrease in attendance the past year may be accounted for in several ways. The present popularity of the French School of Design, has attracted more than usual to the Ecole des Beaux Arts. The financial and labor troubles have reacted directly upon the architects, and caused many young men to choose some profession in which the immediate prospect seemed brighter. A little foresight should show them that conditions would again be normal by the time of their graduation. The courses as now planned, may not be suited to the needs of the profession, but if this is the case, there should be some one with satisfying argument behind his convictions to point out the defect.

TABLE II.

	Depart. of Arch. established.	Length of Curriculum.	Entrance Requirements.	Attendance 1899-1900.	Attendance 1896-1897.	Attendance 1887-1888.	Degree conferred.	Tuition.
Mass. Inst. of Tech........	1869	4 years	A	97	120*	65	B. S.	$200.00
Cornell........................	1871	2 and 4	A	43		67	B. of Arch.	125.00
University of Illinois.....	1871	4 years	A	54	68	44	B. S.	Free
Syracuse......................	1873	2 and 4	B	26			B. of Arch.	120.00
Columbia......................	1881	4 years	A	76	100		B. S.	200.00
Tulane..................	1884	4 years	B	5	4		B. of Eng.	105.00
Case School of Science....	1888	4 years	A	2			B. S.	100.00
Pennsylvania	1890	2 and 4	A	56	70		B. S.	150.00
Chicago School of Arch...	1893	2 and 4	A	27	36		B. S.	75.00
Harvard................	1894	4 years	A	39			B. S.	150.00
Rose Polytechnic Inst.....		4 years	B	5			B. S.	75.00†
Missouri.......................	1899	4 years	B	13			B. S.	Free
Columbian University...	1899	4 years					B. S.	100.00

Total number of Arch. students, 1899-1900, 414, exclusive of M. I. T. freshmen.

* Number in last years. Freshmen are not divided into courses. The total would be about one-third more than given.

† Free to residents of the county.

Architectural Schools of Germany.

Table III. is very incomplete but it serves two purposes; first, it gives a complete list of the technical high schools in which German is the language of instruction, with the number of students in attendance; and second, it shows the proportion of architectural students in six of these schools to vary from eight to eighteen per cent., while according to table II. in Professor Baker's paper, only four per cent. of the

Table III.

Technical High Schools in which German is the language of instruction.	Founded.	Present organization dates from.	Total number of students.	Number of Arch. students.	Per cent. of Arch. students.	Annual expenditures.
Aachen, Germany	1870	1870	1899–1900 542	67	12	
Berlin, ʻʻ		1879	1898–1899 3440	620	18	
Brunswick, ʻʻ	1745	1862	1897–1898 368	48	13	
Darmstadt, ʻʻ	1836	1869	1897–1898 1178	98	8	1897-1898 M. 440,000
Dresden, ʻʻ	1828	1890	1896–1897 903			1896–1897 M. 460,920
Hanover, ʻʻ	1831	1880	1898–1899 1393	258	18	1897–1898 M. 443,500
Karlsruhe, ʻʻ	1825	1865	1897–1898 866			1897–1898 M. 310,722
Munich, ʻʻ	1827	1868	1899–1900 2302	361	16	1897–1898 M. 448,000
Stuttgart, ʻʻ	1829	1862	1899–1900 991			M. 350,000
Zurich, Switzerland	1855		1896–1897 1330			M. 943,000
Brünn, Austria	1850	1873	287			
Graz, ʻʻ	1814	1872	272			1897 Fl. 116,529
Prague, ʻʻ	1806	1868	321			Fl. 104,000
Vienna, ʻʻ	1815	1872	1235			Fl. 317,000
Riga, Russia						

technical students in the United States are architectural students, or, in other words, with five-sevenths the population, Germany has in her technical schools over four times the number of architectural students that are in the architectural schools of the United States.

I believe the schools listed all give instruction in architecture with the exception of Brünn.

As a basis of comparison between these schools and our own, the following information concerning their administration is valuable:

The technical high schools and universities of Germany are all supported by the several States and not by the Empire. This accounts for the differences in their administration, and at the same time is very beneficial, firstly in preventing too great uniformity, and secondly because of the rivalry which it engenders.

The Germans are the most powerful mental factor in Europe to-day. Statistics prove that the scientific publications in German outnumber those in any other language, even the English. It is, therefore, not surprising to find in the German Empire, with its 54,000,000 of inhabitants, the most magnificent technical schools in the world, with beautiful buildings, elaborate equipment and numerous students.

There were in the technical school at Berlin the past semester, 3,804 students—more than one-third as many as there are in all our technical schools and almost 50 per cent. more architectural students than there are registered in the architectural departments of all our colleges and universities.

The authorities upon whom the several schools depend are: For Berlin, Hanover and Aachen, the Prussian Minister of Instruction; for Brunswick, the State ministry; for Darmstadt, the Hessian Minister of the Interior; for Dresden, the Saxon Minister of Public Education; for Karlsruhe, the Minister of Justice and Education; for Stuttgart, the Minister of Church and School Affairs; for Munich, the Bavarian Minister of Education.

The "director" of the Berlin Technical High School is appointed for one year by the heads of the departments of the school, subject to the confirmation of the King; in Hanover and Aachen he is appointed by the Minister for three years; in Brunswick he is elected by the heads of the Departments for three years, but subject to the confirmation of the Regent; in Darmstadt he is appointed for one year by the Grand Duke; in Dresden, by the King for one year, upon nomination of the professors; and the same holds true of Karlsruhe, where the Grand Duke confirms the choice of the professors, and of Stuttgart, where the confirmation rests with the King. In Munich the "director" is appointed by the King for "a certain period of time," not limited by law.

There are four kinds of teachers: professors who are State officials, with a right to pensions, professors who are not State officials, private lecturers, and assistants. Those of the first class are appointed in Prussia by the King, the second by the Minister. The professor is given part of the lecture money, but this has been true only since 1892. In Bavaria all professors are appointed by the King. Three-fourths of the lecture money is given to them and one-fourth is laid aside for fellowships. In Saxony, the first grade of professors is appointed by the King, and the second by the Minister. Those of the first grade receive one-half of the lecture money, and the other half goes to the State. In Würtemberg, where the regular professors are all appointed by the King, the lecture money is likewise given to the State, with the only exception of the private lecturers (privat docenten), who are always given their full lecture money.

An "ordentlicher" professor's salary, in Munich, is, for the first five years, 4,560 marks a year. It is thereafter increased at the end of each five years by 360 marks up to the twentieth year of service, and thereafter by 180 marks at the end of each period of five years. The salary of an "auserordentlicher" professor is 3,180 marks, increased as above. So-called "honorar professoren" receive no salary. At Hanover, the professors are appointed for life by His Majesty the King of Prussia. The average salary is 5,500 marks, with an addition of 660 marks for residence, and one-fourth of the lecture fees.

The students are classed as regular students, "zuhorer," and "hospitanten" (guests). As a rule the matriculation is valid for four years, but "zuhorer" and "hospitanten" are generally registered for one semester only. The students are not limited in the choice of lectures and there is no coercion to visit lectures, except that Karlsruhe and Munich have regulations making it a duty for the student to attend, and at Darmstadt the students must receive a certificate at the end of each term, in which the professor gives them a confirmation of their attendance upon his lectures and demonstrations. In Darmstadt and Karlsruhe, a general tuition fee has to be paid; in the other schools the fees depend on the number of courses, and laboratory work has to be paid for at a higher rate than lectures. There are special fees for the lectures of the "privat docenten," which are determined within certain limits by the latter themselves.

All the technical high schools, with the exception of Munich, and I think Stuttgart, now confer the title of Doctor of Engineering. Formerly there were examinations on the basis of which diplomas were awarded, though in Berlin there was no such examination for architects. The diplomas gave no title nor any special privileges, but were often the ground of awarding prizes and fellowships. There are State examinations for persons desiring to enter the service of the State, which, however, have nothing to do with the diploma examinations (with the exception of Munich, where the diploma examination is equal to a State examination for the departments of architecture and engineering). Foreigners are not eligible for this examination, and in Darmstadt there are special examination regulations for them.

Students who have completed courses at a "gymnasium" or a "realschule" (a high school without classical language), or an industrial school, with a course of nine years and including two foreign languages are admitted without examination. This variation in entrance preparation is offset by the length of time required for the completion of the course, which varies from seven to ten semesters. (See Table IV.) Foreigners may be matriculated upon presentation of testimonials showing their preparation to be equal to that required of German students.

The Swiss Polytechnical School at Zurich is supported by the entire Swiss Federation and is controlled by a Board of Trustees, nominated by the Federal Council (the name given to the Swiss Ministry at Berne). The "direktor" of the school is appointed by the Trustees for a term of two years and he is not eligible for more than three terms.

There are four classes of teachers: professors, assistant teachers, private lecturers, and assistants. The professors are appointed for life and are pensioned when they cease active service. The professors and assistant teachers are given one franc of the lecture fee for each semester lecture, but the private lecturers receive the entire fee.

There are two classes of students, "schüler" and "zuhörer," who are received after reaching a certain age, upon passing the required examinations. They are required to attend lectures under penalty of having their registration canceled, in which case they must apply for reinstatement. Besides the lecture fee dependent on the number of lectures, there is a general instruction fee and fixed fees for library and laboratories. At the end of each year there are examinations in all required subjects which the student must pass before beginning the work of the following year.

The Austrian technical high schools are under the direction of the University of Education at Vienna, but the management of each school is entrusted to the faculty, which include all "ordentliche" and "ausserordentliche" professors and two representative members of the private lecturers, elected for one year. This body elects the "rector" for a period of one year, subject to the approval of the minister, and is responsible for all matters pertaining to instruction, discipline and finance. The professors are appointed by the Emperor, the private lecturers by the Minister and the assistants by the faculty.

The entrance requirements are about the same as in Germany, but the course of study for engineers and architects is five years. Matriculated students pay a tuition, and those unmatriculated pay a fee depending upon the number of lectures elected.

There are three kinds of examinations: The absolutorium, diploma-examination, and the State-examination. The first is the basis for granting a certificate showing that the student has prosecuted his studies with success. The diploma-examination is passed before an examining commission consisting of the dean of the department, professors, lecturers or other experts. The State-examination is before a special commission appointed by the Minister of Education.

There are a few technical high schools in Austria in which the language of instruction is not German, but they are less important.

Russia supports a German technical high school at Riga, which is under the management of the Ministry at St. Petersburg. There are two classes of teachers, professors and lecturers who are entitled to pensions, and lecturers and assistants who are not. Neither class participates in the lecture fees. The professors have the rank of State officials.

Annual examinations are held and a diploma-examination also, which is oral and requires a thesis.

Architectural Schools of England.

In England an architectural education is not obtained by pursuing a systematic college course. Class instruction is considered supplementary to the instruction which the pupils receive from the architectural practitioners, to whom they are articled, and for which privilege they pay a premium.

Brief descriptions of the following institutes and colleges, which are really the only ones in England interesting themselves in the teaching of architecture, will explain their method.

Royal Institute of British Architects.	
Architectural Association.	London.
University College.	London.
Royal Academy.	London.
King's College.	London.
University College.	Liverpool.

The Royal Institute of British Architects stand in the same relation to the architectural fraternity in England that the American engineering societies do to their several professions in the United States. But the English society, through a desire to obtain for all those entering the profession a systematic course of education, affiliates with itself those who are beginning their technical education and tests them by progressive examinations, the passing of which forms the primary qualification for admission to its class of associates. Each person desirous of qualifying for candidature as Associate R.I.B.A. must pass or have passed the examination or examinations required by the Royal Institute under the provisions of the charter and by-laws and according to a standard fixed, and regulations made, from time to time, by the Council. The examination qualifying for candidature as associate is divided into three stages: preliminary, intermediate and final—qualifying for the grade of probationer, student and associate respectively.

The preliminary examination is to test the general knowledge of aspirants in ordinary subjects of school education, and in such subjects of a technical character as elementary mechanics and physics, geometrical drawing, perspective and freehand drawing from the round. Exemption from attending this examination is granted to applicants who submit satisfactory drawings and certificates from well-known educational bodies. A youth who is thus officially exempted or who passes the preliminary examination is registered as a probationer.

The intermediate examination is to test the probationer's progress in art and science, while engaged as pupil, improver, or assistant in an office, and those passing successfully are registered as students.

The final examination is to test the student's further progress. The programme is framed on the same principle as that of the Intermediate. The work to be done by the student and submitted by him before entering, necessitates good draughtsmanship and an acquaintance with ancient edifices or other well-known executed works, to be gained by actual measurement of them. It requires a knowledge of design and of the practical details of construction. The "Testimonies of Study," with the concurrent work of preparation for this examination, which is written, graphic and oral, occupy the student not less than three years, and no one can be admitted to it under the age of twenty-one years, although in most cases it will be found desirable that he should have attained the age of at least twenty-two before presenting himself. If the student pass, he becomes qualified for candidature as associate. Architects in practice, not less than twenty-five years of age, and chief assistants over thirty years of age, who desire to be admitted as associates can be exempted by special resolution of the Council from passing the preliminary and intermediate examinations, and from sending in "Testimonies of Study." They are then admitted on submission of satisfactory probationary work applicable to their professional position, to a qualifying examination, namely the final above mentioned, which is conducted with especial regard to the requirements of such architects, their works and position being duly taken into account by the Board of Examiners. Candidates as fellows, in addition to having passed the above examinations shall have attained the age of thirty years, and have been engaged as principals for at least seven successive years in the practice of architecture.

The Royal Institute of British Architects was founded before systematic technical education was general, and to no other end could they have more profitably devoted their energies. The actual work of instruction, however, devolves upon other organizations, which have planned their courses with the R.I.B.A. examinations in view, and the only degree sought is the associateship in the Institute.

The Architectural Association, carried on under the authority of the Literary and Scientific Institutions Act of 1854, is really the chief training-school for young architects. It is a society unique in its character and without a parallel, I believe, in any other country or profession.

The objects of the association are: To promote and afford facilities for the study of architecture, and to serve as a medium of friendly communication between the members and others interested in the progress of architecture. These objects are, so far as practicable, carried out by means of papers and discussions, a library, lectures and classes, a studio, prizes and scholarships, visits to works and buildings, periodical publications and by such other methods as the committee may determine from time to time.

The preparatory courses are arranged so that students can prepare in two years for the R.I.B.A. intermediate or final examinations. The complete curriculum is arranged in two divisions with some extra subjects, and extends over four years, and in each division there are two parallel but distinct courses, viz., a course of lectures and classes, and a course in the studio. There is also a school of design conducted by specially chosen and eminent visitors, which may be taken advantage of by members in connection with, or apart from, the studio, according to the fee paid.

For more advanced work there is a school of design and handicraft with monthly meetings, a discussion section meeting twice a month, and a sketching and measuring class, meeting each alternate Saturday afternoon. The instructor or leader in each case is a voluntary visitor, who is a recognized expert in the subject.

The instruction continues through about eight months of the year, and the hours of attendance in the studio are from 6:30 to 9:30 P. M., and in classes and lectures, in most cases, from 6:30 to 8:30 P. M. On the class and lecture side, the time on each evening is divided between two meetings of about an hour each. On some occasions the two meetings are devoted to two different subjects. The scope of the instruction can be very accurately judged from the following list of lectures, which covers the four years' course. A period is two hours, unless stated otherwise.

Mensuration, land surveying and leveling—8 evening periods, 8 afternoon.

Elementary water color class—6 periods of 3 hours each.

Hygiene (drainage and water supply)—6 periods.

Hygiene (materials and construction, ventilation, lighting and heating)—6 periods.

Professional practice, specifications and estimates—6 periods.

Elementary construction and materials—16 periods.

English architecture to A. D., 1500—12 periods.

Outlines of medieval and renaissance architecture in Europe—12 periods.

Construction—10 periods.

Color decoration—5 periods.

Plane and solid geometry—8 periods.

Quantity surveying including the preparation of estimates—6 periods.

Modeling—12 periods of 3 hours each.

Elementary physics, formulæ and calculations, stresses and strains—14 periods.

Materials, their nature and application—10 periods.

Orders of Greek and Roman architecture — 8 periods.

Water color class—3 indoor lessons, 6 afternoons outdoors.

Perspective—5 periods.

The tuition for the entire course as above outlined is about $108.00, and the attendance during the last year has for most of the courses been between twenty and thirty-five students.

University College, London, was founded in 1826 and is supported partly by endowment and partly by fees. Classes for architecture and construction, for architectural and structural drawing, and for estimating are conducted. The session, which commences early in October and closes at the end of June, is divided into three terms. Two courses, A and B, each of forty lectures, are given, all fully illustrated by diagrams, photographs, etc.

Course A, given every Monday evening at 6 P. M., is on architecture as a fine art, treated historically, and a knowledge of "The Orders" is required for admission. The first term, ancient and classic architecture is treated ; the second term, Christian and oriental ;

and the third term, the renaissance and modern styles.

Course B, given every Wednesday evening at 6 P. M., is on construction and assumes a knowledge, on the part of the students, of the materials used in construction. The first term lectures are on brick work, and subjects connected therewith; the second term, masonry and carpentry and iron work; the third term, timber framing and joiner's work. Both courses will be found adapted to the requirements of students preparing for the institute examinations.

Evening drawing classes, established by the Carpenter's Company, and at very moderate fees, are held on Monday, Tuesday, and Wednesday evenings, and classes for quantity surveying are held every Friday evening. It is not obligatory upon students to do evening work, but they are strongly urged to do so.

The Royal Academy School of Architecture, London, dates from the founding of the Royal Academy in 1769 and as it was the first architectural school to be established in England, its history is of special interest.

In the early days, as in the present day, the architectural students were, as a rule, educated in architect's offices. They left school at the age of fourteen, and were articled for seven years. This period has gradually been diminished, so that about twenty to twenty-five years ago, four years was the average and seventeen the age at which they were articled. Now, three years is the rule, and those who pursue a university career do not enter an office until twenty-one or twenty-two years old. During the first century of its existence, the students, after submitting probationary drawings, were required to make, within one fortnight, an original design in one of the exhibition rooms, which admitted them to the studentship. Courses of lectures on painting, sculpture and architecture were given in the evening—six lectures in each course, and at a later period, about 1825, a course of lectures in perspective was added. At a later period, six lectures and six demonstrations in anatomy were given, and in or about 1870—six lectures in chemistry. Beyond attendance at these, the only opportunities for study were those afforded by competitions for, first, the gold medal for an original design; second, the silver medal for measured drawings of some building; third, in 1852, medals for perspective and sciography; fourth, every six years a traveling studentship of £200 for two years' travel. The traveling studentship rotated between the painters, sculptors and architects, and only gold medalists could compete. In 1863, the two years' traveling studentship was confined to painters and sculptors, and an annual traveling studentship of the value of £100 was offered to architects. This prize was offered till 1882, when a change was made in the awards.

In 1870 R. Phene Spiers F.S.A., F.R.I.B.A., was requested by the Academy to draw up a scheme of architectural education for evening classes to meet three times a week. Mr. Spiers had spent three years in the Ecole des Beaux Arts, and had during his term as traveling student, made a special study of the schools of architecture throughout Germany. His report was adopted and he was appointed master of the school, which position he still holds. In 1877, Mr. Street, R.A., offered to undertake duties as visitor, together with other academicians and associates, in the same way as painters and sculptors had always done in the other schools, and this system obtains to the present day with great advantages to the students. Four architectural visitors are appointed for each year, each for a period of about eleven weeks and attending once a week. The hours of the school being from 6 to 8 P. M., only about sixty-six hours can be given to any subject, and on the average the student is only able to attend for forty to sixty evenings. The subject to be treated, therefore, must be a small one and the principal difference between it and those which are given to the Ecole des Beaux Arts, is that it shall be of more practical character. Such subjects as "A Casino in a Park" or "A Governor's Palace in Algeria," would be too vast, and being purely ideal subjects, would not appeal to the students. As a rule, the subjects selected are those on which the visitor is recognized as an expert, and the sectional drawings are worked out to show the proper construction, which, to a student who has spent two or three years in an office preparing working drawings, is not difficult. It is in this respect that the designs prepared are of more real practical value as regards their possible execution, than the purely ideal treatment of the French atelier.

The alterations made in the rewards in 1883 were as follows: In alternate years the gold medal was coupled with a foreign traveling studentship of £200 for one year and an English traveling studentship of £60. Premiums of £25 and £10 were given for the best designs in the upper and lower school, and only students in the upper school could compete for the traveling studentships. Two medals, as before, were given for the measured drawing—£10 premium for the plan of a building, a silver medal for perspective and sciography, and about ten years ago, a silver medal for an original composition in clay was added.

Up to about 1880, the student was admitted for two years, and, besides the designs, he had to make studies from the cast. Two complete designs and one cast and a certificate of attendance at the lectures were required before entering the upper school. About five or six years later the course was extended to three years, with two years more after passing into the upper school, and the latest age limit at which students could enter was fixed at twenty-three. This was afterwards increased to twenty-five years for sculptors and architects. The drawings required for admission to the upper school were two complete designs, one cast drawing from the round, an outline of a Corinthian capital, 18″ high, and a geometrical drawing from memory done during the day-time in six hours, 10–4, of some building in London, the subject of which was given out one month in advance. Attendance at the lectures on painting, sculpture, architecture and perspective was also required. On admission to the upper school, two complete designs had to be made before the student could compete for the traveling studentships, and one of the designs had to be sent in for the £25 premium.

During the century from 1769–1870, 740 students entered the school, and about the same number have entered during the last thirty years. Owing to the work of the school being done only in the evening (the competition drawings for the traveling studentships, the measured drawing and the perspective are all done at home), a very small proportion of the architectural students in London become students, and during the past ten years the friendly rivalry of the Architectural Association with its numerous classes every evening, chiefly preparing students for the architectural examinations of the institute, has lessened the number of students in the academy, as they are unable to attend the classes at both institutions. The attractions of the academy are the valuable rewards given (for the gold medal and traveling studentship are looked upon as the highest honor of the young English architect), and the advice given by the visitors who are leading members of the profession.

The Kings College, London, department of architecture was established in 1828 and provides for both day and evening classes. The studio is open from 10 to 6 except Saturday, and students may attend at any time when free from lectures and workshop. The day courses extend over three years and require about six hours a day. They provide instruction in the theory and practice of architecture, and allied subjects as indicated below, and are also specially arranged to enable architects' pupils, assistants, and others to prepare for the institute examinations, the surveyor's institution, the examination for those seeking appointments as district surveyor and building surveyor, and for H. M. office of works, the royal engineers (civil staff), etc. The study list is now under revision, but the present course is given below. The first two years of the day course is attended by students of both engineering and architecture, and the number averages 40; the third-year course for architects only is taken up by few matriculated students, and by but 10 to 12 non-matriculated, exclusive of evening students, numbering about 70.

Day Classes.

First year's course: Building construction, chemistry, mathematics, mechanics, physics, mineralogy and geology.

Second year's course: Chemistry, mathematics, mechanics, and physics in a more advanced form, including practical demonstrations in the chemical and physical laboratories. The lectures on construction include sanitary science, ventilation and heating, mechanics of earthworks, etc. In the architectural studio, constructive drawing is taught.

Third year's course: Architectural history, construction, architectural day studio, including design of modern buildings, sciography, perspective, etc., hygiene in relation to architecture, modelling and wood carving, color decoration, specifications, quantities, professional practice, practical instruction in plumbing, bricklaying, masonry, carpentry and smithing, visits to works in progress, outdoor sketching and measuring.

Non-matriculated students may join any or all of the classes, and if necessary take the three courses in one year. It is desirable however, when time permits, that they should go steadily through the courses, and take the three years to do so. A special course is arranged for students who wish to prepare for the Institute examinations in one year.

Evening Classes: Under the auspices of the Carpenter's Company, evening lectures are given on architecture (Wednesdays, 7 to 8), and building construction (Mondays, 7 to 8), quantities (Fridays, 6:30 to 7:30), and in wood carving.

The session, divided into three terms, lasts from the beginning of October to the beginning of July.

The School of Architecture of the City of Liverpool has been established for six years and offers a complete course of preliminary training, extending over two years, for students to pass through before entering an architect's office, and evening classes for students already engaged in architect's offices. It is not intended to supersede pupilage but to prevent the undoubted waste of time, which too often occurs, when a student enters an architect's office without possessing any previous knowledge of drawing. The plan has met the approval and coöperation of the practicing architects in Liverpool, who have agreed to shorten the term of pupilage, and to reduce the ordinary premium for students thus qualified.

This seems to be the entering wedge which will probably change the trend of architectural education in England and result in a more thorough and complete technical training. The tuition fee is £25 a year for those taking the full course, and special students pay fees depending on the work elected. There are about twenty students in the regular course and thirty specials now enrolled.

The instructors are practicing architects, but almost all their time is required for teaching. The average maximum salary paid is £375 and two-thirds of the fees.

Architectural Schools of France.

France has a national school of architecture, which establishes a precedent for all other instruction in the country, which means as little mathematics as an architect can get along with, and a great deal of drawing and design. The departmental schools are not strong because the competent men will not leave Paris, or else choose to devote all their time to practice, and it is difficult to get good professors for these schools.

The Paris school was founded in 1671 and opened to all without distinction of nationality, and the instruction is entirely gratuitous, with the exception of an incidental feet paid at the atelier.

Admission may be obtained only through examinations, which are held twice a year, and there is a limit to the number admitted, so they have the pick of the students to begin with.

A student to graduate must obtain certain prescribed credits, but above a very low minimum he may elect whatever amount of work he pleases, so that the Frenchman often manages to hold his registration until nearly thirty years of age, while the course may be completed in four to five years.

The Grand Prize of Rome, giving the winner five years of residence in Rome and government patronage on his return, which is open to all native students under thirty years of age, is the incentive to this prolonged studentship. The time not devoted to school work is spent in the employ of the architects of Paris, so that a long-term graduate has very much higher professional training than is possible for our graduates.

The entire method is different from ours. The lectures are given, problems assigned and credits awarded at the school, but the problems and designs are worked out away from the school in ateliers, under the patronage or supervision of a "patron," who is a Prix de Rome man and a practicing architect, and not a professor in the school, as we understand the term. His visits to the atelier are weekly or semi-weekly, and for criticism and assistance the beginners must rely chiefly on the older students.

For full information concerning the organization of the school see "The Paris School of Fine Arts, Past and Present," by H. O. Avery, *American Architecture,* Volume 20, pages 228–230.

COMPARISON OF COURSES.

Table Number IV. gives a comparison of several courses required for graduation in architecture. Berlin is an exception, as the catalogue gives a complete list of offerings, from which the student is to make a selection, under advice of the dean of the department. The table is based on the requirements of the regular architectural courses, and, as it is compiled from catalogue information, doubtless contains some errors due to misinterpretation, but the dissimilarity in the courses of the representative institutions of our own country, which are working with the same object in view, is too great to be accounted for on this ground, and shows the need of concerted action among architectural educators to determine, if possible, what constitutes a well-balanced course.

I regret not having been able to reduce the work of the Ecole des Beaux Arts to a comparative standard, but if it had been possible it would have approximated to that of Columbia, except in mathematics, in which the requirements for graduation are lower than for any of the schools scheduled.

The table is divided into four main columns. All the figures represent semester hours, and one semester hour means one lecture hour per week, with two hours of preparation, for half a year. Three hours' drawing or laboratory work is considered to equal one semester hour.

Column I.—Contains those studies that may be classed under general culture. These include language, history, science, political economy, etc.

Column II.—Includes all mathematical work, including surveying, theoretical mechanics and the lecture part of descriptive geometry. The figures in this column are misleading, unless taken in connection with the entrance requirements as given in Table VI. A further explanation will be given below.

Column III.—Gives the technical work; III*a* gives the lecture work, III*b* the drawing work and III*c* the total amount of technical work.

Column IV.—Contains the total amount required for graduation in semester hours, with the exception of the case of Berlin. No account is taken in this of physical and military training.

TABLE IV.

General Culture.—Language, history, science, political economy, chemistry, physics, etc.

Mathematics.—Includes surveying, theoretical mechanics and lectures on descriptive geometry.

Technical.—Explains itself.

	I. Gen. Cult.	II. Math.	III. Technical.			IV. Total Sem. hours	3 hours drawing per week are counted equiv. to 1 semester hour.
			a Lect.	*b* Draw.	*c* Total		
Illinois.	26	21	38	41	79	126	
Harvard.	22	15	77	55	132	169	5 years recommended for course.
Mass. Inst. Tech.	44	18	23	46	69	131	
Columbia.	12	12	77	73	150	174	
Pennsylvania.	40	14	33	70	103	157	
Cornell.	14	11	40	85	125	150	
Hanover.	17	34	91	66	157	208	
Berlin.	12	48	161	139	300	360	This gives total offerings. Students are advised to make out course under direction of Dean.
Stuttgart.	13	15	65	64	129	157	Course for grads. of Realgymnasium covers 7 semesters.
	25	43	68	74	142	207	Course for grads. of gymnasium, covers 9 semesters.
Munich.	23	28	65	64	129	180	Course Realgymnasium, etc.
	23	36	73	67	140	199	Course Gymnasium 5 years.
	23	32	65	64	129	184	Course Bayer. Realgymnasium. 4 hours mathematics are lacking in entrance as compared with Realgymnasium.
Arch. Asso., London.		3 7/9	5 1/2	9 7/9	8 5/6		

To more clearly show the great dissimilarity in these courses, the following Table V. gives the institutions in their order, with reference to the general culture and technical studies. The figures give the per cent. of the total amount of work under each heading.

Table V.

General Culture.		*Technical.*	
Columbia	6.9	Mass. Inst. Tech	53
Hanover	8.1	Illinois	62
Cornell	9.3	Pennsylvania	65
Stuttgart	8.3–12	Stuttgart	68–82
Munich	12.5	Munich	71
Harvard	13	Hanover	75
Illinois	20	Harvard	77
Pennsylvania	25.4	Cornell	83
Mass. Inst. Tech	33.6	Columbia	86

In partial explanation of Columbia's small percentage of general culture studies, it is but fair to mention that all the subjects in the course are taught by instructors in the architectural faculty, and that they aim to teach some of the technical subjects, so that they shall give a training equivalent to the general culture subjects, usually found in technical courses. This is partially possible, but no architectural instructor is as competent to give criticisms on subjects outside of his profession as is the professor who makes it a specialty.

Table VI.

In the following table is given the detailed work in *mathematics* reduced to semester hours. R means "required for entrance."

The institutions are arranged in the order of amount of mathematics taught in the course, beginning with the lowest.

	Coll. Alg.	Trig.	Analytics.	Calculus.	Mechanics	Surveying.	Theory of Equa.	Total.
Cornell	R	R	2	4	$2\frac{2}{3}$			$8\frac{2}{3}$
Harvard	3	$2\frac{1}{3}$	$3\frac{1}{3}$		3			$11\frac{2}{3}$
Columbia	R	R	4	4	6	2 opt		12
Illinois	3	2	5		4	3		17
Pennsylvania	4	4	6		3			17
Mass. I. T.	2	2	4	6	2		$\frac{2}{3}$	$16\frac{2}{3}$
Munich *a*	R	R	7	7	7	6		13
Munich *b*	4	4	7	7	7	6		21
Munich *c*	4	R	7	7	7	6		17
Stuttgart *a*	R	R	R	R	$9\frac{2}{3}$	6		$15\frac{2}{3}$
Stuttgart *b*	4	3	$3\frac{1}{3}$	$4\frac{2}{3}$	$9\frac{2}{3}$	6		$30\frac{2}{3}$
Hanover	R	R	$2\frac{2}{3}$	12	$7\frac{2}{3}$	3		$25\frac{1}{3}$

From this table the following facts appear: First, that there is considerable variation in the entrance requirements in mathematics, and secondly, that the German schools have the highest requirements in mathematics and lay stress on the mechanics and surveying. They all require calculus for graduation. Massachusetts Institute of Technology is the only one of the American schools listed which gives the same mathematical training to architects and engineers, and at Columbia the quantity is reduced to what is considered to be absolutely essential.

A comparison of the work of these different schools shows that practical experience is an adjunct of the training, in England only; that only in the United States are there any special sequence requirements, or any restrictions as to the amount of work permitted a student; that degrees, except the doctorate in Germany, are granted in architecture, only in the United States, that in all countries except the United States, the professors are practicing architects, which is true to a very limited extent here, and in Germany they are state officials and pensioned after retirement from service; that in Germany, usually during the Easter vacation, the students are taken on excursions by the professors in their own country and even into Italy and Holland for the purpose of studying, sketching and measuring monuments; that in England the coöperation of practicing architects, in connection with night classes has achieved excellent results, but falls short of our idea of an architectural education though all England's best architects have been educated that way.

England, France and Germany educate their own architects, while we are dependent on all of them for assistance.

It must not be expected that a graduate from a well-balanced four year course in architecture will be immediately successful from an artistic standpoint, and as we never can surround our schools with the art atmosphere of the great cities of Europe, it is proper to encourage postgraduate work abroad. If this is not possible, a schooling in the office of an architect, where time is taken to properly study a design, is the next best thing.

Artistic training can be acquired in four years, only at the expense of general culture and construction. In bygone ages the architect was the man of science, and I believe that our first duty, now, is to teach him to build and to be broadly cultured.

The successful French architects have usually devoted four years to their school work and then begun work in an office, but at the same time keeping up their interest and work in the school. This feature is highly commendable and explains the great facility of the French designers.

Fellowships.

To give American students opportunity for such postgraduate study, the following fellowships have been established :

Rotch traveling fellowship ; established in 1883 by a bequest of Benjamin S. Rotch of Boston. The annual value is $2,000.00, and it maintains two traveling students abroad. The award is made annually and for a period of two years. The fellowship is only open to students or draughtsmen who have spent two years in some architect's office, in the State of Massachusetts.

Columbia fellowship; established in 1889, was the third endowed course of study in Europe available to architectural students. It was founded as a compliment to Mr. F. A. Schermerhorn, to whom Columbia University owes its department of architecture, which was established and endowed at his instance and expense. The fellowship is awarded in the spring of every even-numbered year, and has a value of $1,300. Only graduates of the Department of Architecture of Columbia University, under thirty years of age are eligible, and the income must be expended in foreign study and travel in accordance with approved plans.

McKim fellowships; these two of $1,000 each are awarded under the same conditions and with the same object as the Columbia fellowship, and upon alternate years.

Perkins fellowship: a travelling fellowship of the value of $1,000, from a bequest of the late Willard B. Perkins, will be awarded in the spring of every fourth year, beginning with the year 1902. The conditions governing the holders of this fellowship are the same as the Columbia fellowship.

The Cornell College of Architecture possesses a Travelling Fellowship and a Resident Fellowship. The Travelling Fellowship of the value of $2,000 is awarded in alternate years to the winner in an architectural competition. The first competition was held in October, 1898, and the second will occur during this summer or fall. Candidates must be under the age of thirty and must be either graduates of the College of Architecture, or have satisfactorily completed the two-year special course.

A Resident Fellowship, of the annual value of $500 is open to all graduates of schools of architecture of approved standing in the world. The award is made in June for the following year, and each candidate must submit drawings and other credentials, and file a formal application with the Registrar of the University, on or before April 15.

Austin Travelling Fellowship; a fellowship, of the annual value of $1.000, open to Bachelors of Science in Architecture, from Harvard University, who have taken the degree with distinction.

The John Stewardson Memorial Travelling Scholarship; this scholarship is under the control of the Department of Architecture of the University of Pennsylvania, and is open to architectural draughtsmen in the State of Pennsylvania, over twenty-one years of age.

The Perkins Graduate Scholarship; founded at Massachusetts Institute of Technology by bequest of Willard B. Perkins, of the class of '72. The income of $6,000 is available in every fourth year for a travelling scholarship in architecture.

Architectural Club Fellowships; the Boston Architectural Club and the T-square Club of Philadelphia have established travelling fellowships to be competed for by their own members, which have proven a great stimulus to club work.

No other country offers such advantages to her architectural students. It is true that in France the Prize of Rome opens to the fortunate winner a reputation and assurance of future employment, which the American fellowships do not, but to offset this, the possessors of the American fellowships are less hampered in the matter of the course of study to be pursued. Practically they may follow their own inclinations, and being generally men who have had a certain amount of practical experience, they know what they want, and go about getting it in a most business-like way.

The American School of Architecture at Rome is established in the Villa Ludovici, on Quirinal Hill, and holders of fellowships have the advantage, while there, of the assistance of a resident advisor.

CORRESPONDENCE SCHOOLS.

In considering the present status of architectural education, we cannot ignore the work of the correspondence schools, which now have enrolled more than ten thousand students in architecture. The education given is not scholastic in character and a graduate is not a fully educated man, but it is possible, by this method of instruction, for a persevering student to obtain a specialized education in the principles and practical applications of the various divisions of architectural work.

These schools are not rivals of the colleges, nor can they ever be preparatory to college courses. They reach a class which cannot avail themselves of a higher education, and they must be given due recognition for their work.

I have presented here various methods of architectural instruction. There is merit in all, but the ideal plan is yet to be evolved.

DISCUSSION.

PROFESSOR AYRES hoped that Professor White would say a little more on a phase of architectural education which interested him, and that is, to what extent the colleges which are looking at architecture in a serious way should yield to the traditions of the artist. He thought that the reason there are so few architectural students is because the tendency to make the course artistic rather than engineering has been steadily resisted. The speaker believed that the architect, while having the artistic temperament, should, first and foremost, be an engineer. That it is not sufficient that he should make a pretty picture of a house, but that he should be able to make a good *house*; and, with the growing complexities of building construction, calling for an increasing amount of engineering knowledge, it had seemed to him that the man should be given a sound engineering training. He knew that in the University of Illinois a distinction is made between the architectural engineering and the architectural courses. It seemed to him that, unquestionably, there is need for architectural training in this country, and that the movement which had been carried out successfully, apparently, in Illinois, resulting in a law regulating the practice of architecture, is quite an important advance. One difficulty which Tulane University had found in trying to develop an architectural course was that the architects themselves have been against the plan. They preferred to have the young man who wishes to study architecture as a profession enter as a draughtman in their offices at a very small salary, while the University wants this young man to come to college; and the fact that the architects are thus opposed has kept away a considerable number of serious-minded young men, who would otherwise be willing to submit themselves to the training of a real engineering course. Their professor of architecture, however, had always urged the speaker to allow the young men to come in with less mathematics, and to allow them to put in more time on pure art subjects. He wished to hear something more from Professor White as to how much that point has been yielded at other institutions.

Professor Woodward responded to the query just raised. At Columbia, he thought their professor of architecture took the ground that an architect should be, first and foremost, an artist. They draw no sharp line, but a distinction is coming to be recognized between the architect and the architectural engineer, and stress is laid upon the artistic side of the instruction of architects. As soon as a student in that course enters the Columbia School of Architecture, he is differentiated from the engineer. He begins special work and the work in mathematics and mechanics given to the student is special, and given by the professor of architecture. Personally, the speaker had been opposed to this method. He thought that the instruction in mechanics should be given by the department of mechanics, just as the instruction in physics should be given by the department of physics, and not by one connected with the school of architecture. On the other hand, it must be admitted that the plan thus far followed, or the plan that is now in operation, seems to work pretty well. He thought their school of architecture was turning out good men.

The speaker mentioned another point, which seemed obscure in the paper just read, where something was said about the mathematics at Columbia being less than that of any other institution. It is quite possible that the catalogue statements would not enable one to understand clearly what is done. A good deal of work is done in mathematics with the students in architecture, but it is work which the professors of architecture think is specially directed and adapted to the needs of the student in the work of architecture. Much more attention is given to culture subjects in the course in architecture than in any of our schools of engineering, such as reading works on architecture in foreign languages, for instance.

DEAN ALDERSON: The course in the Chicago School of Architecture is given jointly by the Armour Institute of Technology and the Art Institute of Chicago. The mechanics, science, and mathematics, are given by the same instructors who teach these subjects to the engineering students; but the emphasis is laid upon the artistic side. The Art Institute authorities have the most influence in all considerations with regard to the course in architecture, and so different are the conditions there from those mentioned by one speaker, that there is a committee of practicing architects in Chicago who regularly visit the Art Institute and give it every assistance in their power, by criticism and suggestion. In conclusion, it may be added that perhaps Chicago, more than other places, needs special artistic training.

Professor Fletcher remarked that, doubtless, many engineers have become aware of the fact that, among architects, altogether too little attention has been paid to constructive details, and that probably many members of this society have seen the grossest designs, so-called, for roof trusses and other important structures, that violate every principle of mechanics; for instance, heavy roofs, exerting a great thrust at the foot of the rafters, without any adequate tying together: and the speaker has quite a collection of these curiosities and atrocities of design. Undoubtedly the construction of the tall building has brought the architect and the engineer closer together, and it seemed to him that the art side has been given altogether too much attention, especially as the architect assumes responsibility for the structure, and frequently leaves work behind him which is grossly inadequate and faulty.

Professor Allen said that similar thoughts had occurred to him, in relation to the artistic work of the architect. The work sometimes suffers from the fact that he has not proper ideas of construction. His artistic design is often incorrect in structural principles, and it is to that extent a bad design. It is quite necessary for the architect to go far enough into engineering, or have some one in his employ to check his designs sufficiently, so that what appear to be structural defects shall not mar the design, even though some hidden features do, in fact, make the structure safe.

THE MANUAL TRAINING HIGH SCHOOL IN GENERAL AND IN ENGINEERING EDUCATION.

BY EDWARD A. BENDING.

Principal Dayton Manual Training School.

In presenting this paper to the Society for the Promotion of Engineering Education, it is my desire to call attention to three points in regard to the manual training high school.

1. To touch briefly upon the place it is filling in general education, its aims, what it has accomplished, and the good that has accrued from it; not that the Society is unfamiliar with the subject, but, being engrossed in its own and much higher lines, its members have given it but a passing thought.

2. To create, if possible, a more harmonious relation, more concerted action, and more coöperation between the college of engineering and the manual training high school, for reasons which shall be enumerated, and a more general recognition of the work that is done or can be done at these schools.

3. To obtain, through discussion, the general opinion and subsequent adoption of reports from this Society as to what the manual training high school should do towards engineering education.

Scarcely twenty-five years have elapsed since the manual feature in education had its beginning. The educators of the nation no longer question its value. As its advocates have slowly dropped the "only" and the "all in all" appellations, and let it assume its proper place as a great educational force in a great system of education; so has it come to be accepted by its opponents and by sound thinkers, and through them received its greatest impetus.

The magnificent endowments and the sums appropriated for their support show that these schools are fully established in the hearts of the people. The high school has been called the "People's College," but without the manual feature it comes far from being such.

Among the aims and claims of the work are the following: 1. The most prominent is its aim and success in giving a broader and more liberal education. 2. The cultivation of the power to think and act in unison. 3. "Learning by doing." "The coördination of the sensor and motor neurological systems." 4. Its aid in developing concentration of thought and attention. 5. Its aid in discipline, in physical culture, in observation, in forming clear conceptions, judgment of size and form, self-expression, originality and individuality.

In fact, there seems to be nothing on the list of attainments that manual training does not cover. But when we consider what our educational system has done in the past and then add to this a broadening process, another mode of expression which is sure to result in "lateral expansion and longitudinal extension," it cannot be considered marvelous that so much will result as a matter of course; and the many claims are but the just claims of education in the broad sense of the word.

From an extended correspondence with manual training schools throughout the country, from catalogues and general observation, I am led to make the following statement: A greater percentage of the graduates of these schools enter higher institutions of learning than do those from the high schools without the manual feature. The positions obtained by graduates are also of much more importance and more remunerative.

It is claimed that but ten per cent. of high school graduates go on to college, but the percentage of manual training high school graduates that enter technical and engineering colleges alone is from fifteen to fifty-five per cent., or an average of thirty-five per cent.: and to this must be added those who enter other higher institutions of learning.

This leads the writer to believe that not only is the manual training high school, as it stands, the best preparation for other colleges—and this conforms with the opinions of the departments of engineering in fifteen of the leading colleges—but that it is, or may be made, the best preparation for the engineering college. This last statement will not meet the approval of all, for in a correspondence, to be referred to later, some said the time spent in a manual training high school by a prospective engineering student, was time wasted, while others said time spent in a Latin or classical high school by the same class of students was time wasted. The consensus of opinion was, however, that the former would be the better preparation.

Aside from the good to general education, these schools are filling a place which, to the writer, is one of the greatest any institution can attain, viz., a place in the hearts of the masses; the workers. A favorite question of mine upon entering one of these schools is "what percentage of these boys would be here if the manual feature were taken away?" The answers have ranged from seventy-five to twenty per cent. This means that a great percentage are being educated who would otherwise have discontinued all study upon completion of the grammar grades, and the majority of these are sons of mechanics or boys with strongly marked mechanical tendencies. Give such boys as these an insight into and a desire for higher education, and upon completion of the high school course, individual efforts are put forth for it, and as a result we have recruits of the best kind for engineering education.

The majority of those who find work immediately upon completion of the course are after a few years found in technical and semi-engineering pursuits, the list of graduates showing that they can and are doing excellent service as draughtsmen, designers, foremen, superintendents, etc.

"Out of 13,000,000 young men in the United States between the ages of sixteen and thirty, only five in every 100 have been prepared by education at some kind of school for their occupation." "Out of every 100 graduates of grammar schools, only eight obtain their livelihood by the professions and commercial pursuits. The remaining 92 obtained the same by means of their hands. The eight are fitted for their life's vocation and wage earning capacity at colleges, universities and professional schools, while the 92, denied similar opportunities, are obliged, amid great embarrassments, to fight their way for a livelihood by experiment and imitation of other workmen."

Further comment is unnecessary. The great field and absolute necessity of schools for this 92 per cent. demands that the manual training high school, even though aiming at general education, must do its share toward the industrial and lure boys to higher education. Here also is a point well worth the consideration of the engineering college. The paper before the Society at its last meeting, "The Apprentice System in College Shops" was particularly interesting to the writer, who hopes that this means or some other will be adopted by other colleges till the trade and industrial schools are more fully established.

The future is sure to bring forth three types of schools in the scheme of industrial, technical education :

1. The trade or industrial school in its distinct and separate field.

2. The manual training high school in another, aiming only at general education and preparing for engineering colleges.

3. And lastly, and at the top of the scale, the college of engineering. These three are closely interwoven, yet must be as clear and distinct in the minds of the people as black and white ; the two former working into each other's hands, and fostering a desire for and recruiting for the latter.

To get the latest ideas of the principal manual training high schools in the United States, the writer sent out circular letters to twelve of them asking the following questions :

1. What is the aim and scope, briefly stated, of your school in regard to the college of engineering?

2. What per cent. of your graduates enter technical schools and colleges of engineering?

3. What credit, if any, is given for drawing and shop work?

4. Do the numbers applying justify the establishment of a preparatory engineering course as distinguished from your regular course of instruction?

5. Would you suggest any changes in your present course if the above were established?

6. Have you received from any college of engineering or technical school suggestions in regard to what should be given prospective engineering students or as a preparatory engineering course?

In answer to the first question the most general reply was: We aim at general education and incidentally prepare for the engineering college. Some aim only at general education. The answer that pleased me above all others was from the Boardman Manual Training High School, saying: "We have two distinct courses, one preparing for Sheffield Scientific School (Yale), and in the other we pay no attention to college requirements, but give that which seems best for those whose education ends with the high school." This from an eastern school and from a place where the atmosphere itself is permeated with the classics, leads me to believe that this school has found its true place and may well be taken as a model.

The answers to the second question varied from fifteen to fifty-five per cent., with fifty per cent. the most general. I cannot refrain from again calling your attention at this point to the fact that statistics show only ten per cent. of high school graduates entering colleges, and in this calculation, *the large percentages of these schools under consideration are included.*

In regard to the third question. there was considerable diversity. In fact, not much seemed to be known. The most general answer was: "We get some credit, but no definite arrangements;" also, "different colleges give us credit in varying amounts." One school claimed that "they received full credit for all that was done at their school from nearly all technical and engineering colleges: others none at all, and no school seemed to get much credit for shop work. The replies to this question seem to indicate lack of coöperation between the colleges of engineering and the high schools.

The answer to the fourth question is of psychological or else of geographical interest, because all eastern schools answered "yes," and all western schools "no."

The answer to the fifth question was quite generally "no, because our course at present seems to be just about the right thing." A question arises here as to how this is known when the sixth question was answered "no" by all the schools with one exception. A few suggestions in regard to the addition of descriptive geometry and surveying as electives in senior year, were given.

From the correspondence as a whole one might be led to believe that engineering colleges recognized and gave credits for a portion of the shop work and drawing if they knew what had been done, but there is no general recognition; that the manual training school can, does to some extent, and desires further, to prepare for the engineering college, and that they have received very little encouragement in so doing; that they have advertised and tried to lead up to this, but not at all in a concerted manner. They have grasped the credits given them as a hungry dog would a bone, and the colleges on their part giving them in a seemingly begrudging manner.

This may be accounted for by the fact that the growth of the manual training schools has been insidious. The colleges have not realized their growth, nor the percentage of recruits that might naturally come from them. The schools themselves, in order to "take" have been handicapped by being compelled to "make a showing," and many have come to look upon them as "show schools." In consequence they have gladly accepted just what was given them. This time has passed and an examination of the courses of study shows as strict a compliance with the report of the committee on college entrance requirements as any other high school, and, in addition, three or four courses in shop work and mechanical drawing, which in no way detract from the culture studies, but give an added force and in many schools permit the pursuit of more advanced mathematics and science. Excellent authority from all parts of the country attest that this is the case.

The following questions were directed to fifteen of the leading engineering colleges in the United States:

1. What credit, if any, is given for drawing and shop work to graduates of manual training high schools who enter your college of engineering?

2. Have you observed any appreciable difference in the manner with which a manual training high school graduate pursues your engineering courses as compared with the graduates of other high schools? If so, what?

3. If such exists, to what do you attribute the disrepute, so to speak, in which manual training high schools are held by colleges of engineering, especially by instructors in the latter?

4. Would you advise a prospective engineering student to attend a manual training high school in preference to a Latin or classical high school?

5. In your shop courses do you aim at the educational feature and facility of hand or at the industrial and economic feature, fundamentals of tools and trades, shop processes and general construction?

6. If the fundamentals of tools, facility of hand, etc., could be gained before entering the engineering college, could not the time be used to better advantage in construction work, as distinguished from exercises, and in the engineering laboratory?

7. Why is so little credit given for shop work done at manual training high schools?

8. What is the essential difference between the shop course of your college and the best manual training school in the State?

A summary of the replies to the first question appeared quite liberal and more encouraging than those received from the manual training schools. In every case credits are allowed to the extent the individual case justifies. The college shops are organized on the basis that young men know nothing about drawing or shop work. The first year's work is given solely to gain facility of hand and a general knowledge of tools. Then the real work begins.

To the second question the replies were quite in favor of the manual training graduate. "They are more apt," "quicker to learn" and "make better average progress in all studies related to the technical school than do men with merely a literary or classical training"; "as a whole, a better candidate for our requirements"; "they have a better comprehension of mechanical matters"; "they take hold of the real engineering work much more rapidly," etc., though the complaint of lack of preparation in the languages was quite general with this question.

The third question was universally answered "not so held." The word "disrepute" was perhaps a little strong, but immediately following, many statements were made as to what these schools lacked, should not do, and did not do. Quite general was the statement that the manual training graduate had a too exalted opinion of his work as applied to engineering. This is of course the fault of the school from which he came and in all probability elementary engineering was attempted. Merely the facility of hand, use of tools applied to different shop processes, and a thorough foundation in mechanical drawing should be given. For my own part I think that the mechanical drawing should cover projections, enough machine work to familiarize the student with the shop drawings, and the rest of the time devoted to descriptive geometry, with perhaps a little architectural drawing. The elaborate displays in both drawing and shop work of some schools shows much valuable time thrown away. This latter is the key-note of the many criticisms elicited by the third question.

The fourth question brought out the fact that the majority believed the manual training school would be the better but in almost every case a protest was entered against the manual training school that did not teach the classics and the classical high school that did not teach manual training. All believed that the prospective engineering student should have both in his preparatory course.

Answers to question five indicated that the economic feature, trade and shop processes, and general construction were the aim, but that valuable time was consumed in teaching manual expression, use of tools and facility of hand. This is the strong point in favor of the manual training school for preparation.

Question six was answered as a continuation of No. 5, and quite generally agreed that time could be saved, better and more advanced work taken up, some even claiming that with a good manual training high school course as preparation, the college course could be completed in three years, leaving the fourth year for postgraduate work.

Question seven was answered in questions one and two, with opinions that the shop work was not so good on the whole as the drawing.

Question eight shows in the majority of cases where anything at all is known that the manual training school shop and drawing courses are quite similar to the first two years' courses in the engineering college, though as a matter of course, the work is given from the engineering and not from the pedagogical point of view. The work in college necessarily extends over a longer period, and after excellency in workmanship, which is a strong feature, is gained, students take up much more advanced lines of work. This excellency in workmanship could and should be gained before entering the college, enabling him to take up advanced work at once. It is a case of beginning arithmetic in college.

The correspondence shows that the colleges are willing and do recognize the work of the manual training school, when properly taught. That they prefer as a whole the manual training graduate, and that if properly done, his shop work and drawing help him very materially and save considerable time, enabling him to advance and devote more time to the purely technical studies. Statements were made by two or three colleges that they received more applicants from manual training schools than from any other public or private schools. This probably is not general as yet, but will eventually become so. The tendency of this Society, from reports of previous meetings, points to more uniformity in engineering courses, less shop practice, more engineering laboratory practice, the pursuit of pure technical studies and specialization in engineering courses, as is done in law and medicine. To do this requires time. It is out of the question to suppose, as has been suggested by some, that a student can take his high school course, then a course at a liberal arts college, and a final course in engineering. Short cuts are the ones taken. The high school is and will continue to be the preparation for colleges and universities. If the manual feature can be added to the usual courses with no loss, but a decided gain, as has been proven, here is the solution, and it is the duty of the engineering colleges to help build up these schools. Both sides seem willing.

That the engineering profession has reached the top of the scale is shown by the responsible position its members are called upon to fill, and the varied conditions under which they labor. The engineer graces equally well the lecture platform, the reception room, the office, the factory, the mountain fastness, the backwoods, and the bowels of the earth. His training must be broad. What preliminary education can be more broad than the one that cultivates all the powers of expression?

In conclusion it may be added that the colleges of engineering have not done what they should do for the schools from which the majority of their future recruits are to come. Let there be more coöperation. Let them get in touch with the manual training high school and lend a helping hand. A few suggestions and words of encouragement do a great deal. The engineer above all others should look long and well at the material from which he is to select.

The manual training schools have done much and with the coöperation and assistance of the engineering colleges will do more. Not only this, but their encouragement and recognition will establish more of these schools, and for every one established, a thousand blessings from the hearts of the industrial masses are heard.

WHAT SHOULD BE THE CHARACTERISTIC FEATURES OF THE TEACHING OF A COURSE IN MATHEMATICS FOR ENGINEERING STUDENTS?

BY ARTHUR EDWIN HAYNES,

Professor of Engineering Mathematics, University of Minnesota.

In the opinion of the author, one may the more accurately judge what the features of such teaching should be by pointing out the results sought, and then giving attention to the way in which they may be attained.

It may be declared of such teaching:

(*a*) That it should be of such a character as to produce an enduring, stimulating effect upon the mind of the student.

(*b*) That it should give the student the power to properly interpret mathematical language, and to accurately and skillfully use it—and

(*c*) That to secure these results the teaching must be based upon a proper order of studies, and carried forward in an intelligent, rational way.

Mathematics may be studied with two objects in view, the first of these being mental discipline, and the second, the application of its principles to the solution of practical problems, or their successful use as a tool. In the ordinary literary course the first of these objects takes the primary place, while the second receives comparatively little attention. On the other hand, in a course of engineering mathematics, while the first of these objects cannot wisely be neglected because a knowledge of principles forms the best basis for their intelligent application, yet the second object reaches its maximum importance in such a course. No one can be a first-class practical engineer while unable to skillfully apply the principles of the science which so largely form the very foundation upon which his professional knowledge and practice must be built.

Under the first sub-head (*a*) it may be remarked that in order to produce this permanent, healthful, stimulating effect upon the mind of the student, the mind of the teacher must possess an untiring interest, first, in the subject, and second, in the student himself; the first being due to a proper appreciation of the practical value and importance of the subject, and the second, to a just estimate of the possibilities of the student.

After an interval of over a quarter of a century, I find that these two are among the most marked and valuable characteristics of my early teachers in mathematics. One of the finest examples of this enduring, stimulating mental effect is exhibited by a former honored president of this society, Dr. Henry T. Eddy, whose strong, productive mind seems to possess all the unabated interest of his early student life, combined with the riper thoughtfulness and the more mature zeal of later years. I have been forcefully impressed with this feature of the power of his early teachers, in reading mathematics with him during the past year.

Blessed is the teacher whose teaching thus enables him to enduringly stimulate the mental activities of the student. They who are so fortunate as to come under the influence of his instruction will have no thought of planning a "funeral" for the text-book; they will rather feel like chanting a hymn of gratitude for so great a privilege. It is such power that constitutes the first feature of the teaching advocated in this paper; it is such power that caused Kepler to exclaim, when he had won an immortality of fame by the discovery of the third law of planetary motion: "Glory to my old master!"

Under the second sub-head (*b*), with reference to the proper interpretation of mathematical language, perhaps a very simple illustration from analytic geometry may suffice to give the idea. In passing it may be in order to remark that in this study we find the use of, at least, three languages required, all of which may be truthfully said to be mathematical, and in many instances the student is required to express each in terms of the other. For example: Find the locus of a point so moving in a plane as to be a constant distance (R) from the point (a, b) in that plane. This language is mathematical. but it may be interpreted in mathematical (algebraic) symbols, thus $(x-a)^2+(y-b)^2=R^2$, and this, in turn, may be re-interpreted in another mathematical (geometrical) language, the language of form, thus giving the locus required, including its shape, size and position.

So the teaching of the student should have given him the power to correctly understand the language in which the problem is stated, to translate this into the language of a properly expressed equation, and, when required, to accurately re-translate this into a geometric figure: thus is the sense of the sight made helpful, by being employed to observe the developed picture, secured by the second translation, which the subtle chemistry of the brain had involved in the first translation, or in the algebraic equation.

The accurate and skillful use of mathematical language can be secured only by the careful solution of many problems in which it is involved. These problems should be of a practical character and, as far as possible, should illustrate the way in which the principles of mathematics are used as a tool in the engineer's profession. In fact, here is the proper vantage ground of the well-qualified teacher—the very place where the attention of the student may be secured, his interest aroused, and the stimulating effect mentioned under (*a*) intensified and made a living reality.

A second characteristic, then, of the teaching advocated, is that it is thoroughly practical and gives the student an acquaintance not only with the theory of the instrument, but teaches him as well how to use it successfully.

A good text-book is of great importance in such teaching. The practical character of engineering mathematics requires a marked differentiation from that of the ordinary text-book in the treatment of the subject. It is a matter of congratulation, therefore, that our more recent text-books in mathematics for engineering students recognize this feature, and, as a consequence, they are rapidly improving in contents, in method and in arrangement.

Under the last sub-head (*c*), which calls attention to the proper order in which the studies of such a course should be taken and the methods which should prevail in such teaching, there may be various opinions. Some of the questions which arise under this head are:

1. Should the algebra and trigonometry of such a course be taught in succession or simultaneously?

2. The same question may be asked with reference to the differential and the integral calculus.

3. Another question is, should the elements of both the differential and the integral calculus, with some of their simplest applications, be taught early in such a course before the analytic geometry, as such, is completed?

4. Should the study of the more abstruse parts of algebra and trigonometry follow the study of the calculus?

5. And again, it may be asked, how far is it advisable to use the lecture method in the teaching of such a course to undergraduates?

With reference to these questions I can only answer, as seems best, from my somewhat extended experience and observation, with the sincere hope that my contribution may add something of worth to the literature of the subject. In answering each of these questions, however, one must keep constantly in mind the objects expressed in (*a*) and (*b*) and remember that undergraduate teaching is that to which reference is made in this discussion.

In the college of engineering, in this university, I have found the study of algebra and trigonometry *together* to be especially advantageous. In the Freshman year the algebra is taken three hours per week during the first two terms, and is followed by plane trigonometry two hours a week during the same terms. During the third term of this year, the beginning of analytic geometry alternates with spherical trigonometry two hours each per week.

Illustrations of the mutual advantage of this method are found in the algebraic solution of trigonometrical equations; the trigonometric solution of the cubic equation; the trigonometric representation of the roots of an equation of any degree, having all its roots equal; the graphic representation of complex variables and the various operations upon them; the graphs of the trigonometric functions; the trigonometry of the right line, etc. By this method, too, both the algebra and the trigonometry are kept in mind long enough to make a more enduring impression than when taught otherwise.

With reference to the best order in which to teach the calculus, I am of the opinion that both branches of it, viz., the differential and the integral, may be taught to advantage *together*. My experience, however, in the main, has been to teach them by recitation, separately, four hours a week in successive terms, and to combine them in teaching by a lecture, one hour each week, during these terms.

In the beginning of the Sophomore year, early in the study of analytic geometry, a short time is given to the elements of the differential and the integral calculus and some of their simplest applications, thus enabling the student to carry on his work in physics, at this point, more successfuly, while it gives him an opportunity to appreciate, in some degree, the practical value of mathematics as an aid, in conducting his investigations. This method also encourages the student to still greater proficiency in the study, whose utility thus becomes apparent to him.

I am constrained to the opinion that the study of the more abstruse parts of algebra and trigonometry might, with decided advantage, be made to follow the study of the calculus.

And lastly, I believe that, in the teaching of mathematics to undergraduates, the lecture method should be reduced to a minimum, and that nothing else, in such teaching, can have the efficiency of the continuous, steady power of the well-conducted recitation.

THE POSSIBILITIES OF CORRESPONDENCE INSTRUCTION.

BY GEORGE A. GOODENOUGH,

Assistant Professor of Mechanical Engineering, University of Illinois.

The rapid growth and the extraordinary financial success of the correspondence schools has deservedly attracted the attention of educators; and there has been much speculation as to the proper position of the correspondence system in engineering education. Will the correspondence schools, as at present constituted, gradually advance their standard of excellence, and ultimately graduate engineers; or will they rather provide in a measure the secondary technical instruction that in Germany is provided by the trade and monotechnic schools? In other words, will the correspondence schools turn out skilled engineers or skilled workmen? Has the correspondence method of instruction intrinsic merit or is it to be considered merely a makeshift? Finally, if it be assumed that instruction may be imparted thoroughly and effectively by correspondence, has the correspondence method any possibilities as an auxiliary to the regular State school system? These are the questions that present themselves to educators.

In considering the probable influence of existing correspondence schools upon engineering education, it is necessary to outline briefly the conditions under which these schools have been and are at present working.

There are, I believe, six correspondence schools giving instruction in technical subjects. All of them are private enterprises. The total enrollment of these schools must be approximately 250,000, as the Scranton School alone has an enrollment of 200,000 students and graduates, and that number is increasing at the rate of 10,000 per month. The different schools give technical instruction of substantially the same character. In fact, the leading courses of one or two schools have been largely borrowed—to use a mild term—from an older school. There is some difference between the schools as regards the range of subjects offered ; some confine their efforts to one or two leading courses, while others offer instruction in almost every technical subject and some that are not technical.

According to a late circular, the International Correspondence Schools of Scranton—by far the largest and most influential of the correspondence schools—offer 47 regular courses and 20 special courses. Leaving out of consideration the non-technical courses, such as English branches, commercial, and electro-therapeutics, the remaining courses may be roughly divided into two classes : 1. The *engineering* courses proper, as the complete mechanical engineering, electrical engineering, bridge engineering, etc. 2. The *trade* courses, as sanitary plumbing and gas-fitting, lettering and sign-painting, sheet-metal pattern drafting, etc. There is no sharp division between these classes, many of the courses lying near the border line ; thus telephony, electric railways, refrigeration and farm machinery are rather more than trade courses, but they cannot be classed as engineering courses.

The courses of class 1, though elementary, are fairly complete; the preparatory papers include algebra, trigonometry, mechanics, hydromechanics and pneumatics, and the succeeding technical papers are as a rule well written and up to date. The earnest student that masters one of these courses is fairly well equipped to enter the lower walks of the engineering profession. He is far in advance of the "pocketbook" engineer, and he is perhaps not so far behind the graduate from the college or university as we are prone to imagine.

The courses of class 2 are decidedly elementary. The mathematical preparation is weak, consisting of arithmetic, mensuration, and elementary mechanics, and each course consists largely of papers descriptive of the trade with which it has to deal. Graduates of these courses may be classed as educated workmen.

Of those that enroll in the longer and more difficult engineering courses, only a small percentage finish their courses. The preparatory mathematical papers, though elementary, prove too trying for a large majority of the students. In the shorter trade courses, the student reaches the practical papers earlier in the course, and the percentage of students graduating in these courses is much larger than in the engineering courses. The problem of keeping students at work until they finish their courses is perhaps the most serious that confronts the correspondence schools.

The recent increase in the enrollment in the correspondence schools must no doubt influence the future attitude of the schools. When the advertisement in the technical journal was the only medium used to secure enrollments, it is reasonable to suppose that the majority of the students were men earnestly desirous of an education and willing to undergo some hardships to obtain it. At present only a small percentage of the 10,000 that enroll every month do so on their own initiative. Most of them have been persuaded by solicitors, and have taken a course on trial, so to speak, on the $2-per-month installment plan. Now of these 10,000 few are capable of taking the more difficult courses. Recruited as they are from shops and factories, they as a rule wish merely for a stock of practical information in the line of their respective trades, and care little or nothing for studies of educational value.

The correspondence schools are confronted, therefore, by these conditions: 1. With the increase of students, the number of students that demand the engineering courses is growing relatively smaller, while the number that demand the trade courses is growing relatively larger. 2. The students in the more difficult engineering courses are more likely to lose interest and drop their courses than those in the shorter and easier trade courses. In view of these conditions, it is not strange that there is at present a strong tendency towards the short specialized courses. Professor Marburg in a paper presented before this society last year said "it is believed that any attempt at giving by the correspondence methods a really thorough education to persons who at the same time follow their daily occupations must end in failure. Narrow and shallow courses, of the kind described, may be regarded as the inevitable issue." While I am not prepared to assent unreservedly to the first statement, the second statement admits of no question, so far as the existing correspondence schools are concerned.

Some of the correspondence schools, however, must be given credit for sincere efforts in the opposite direction. The managers of one school, at least, have all along earnestly desired to improve existing courses and to add advanced courses comparable with those given in regular engineering schools. During the time I was connected with this school two advanced courses were started and are now partly completed. One is a course in higher mathematics to include calculus and differential equations. The advanced algebra in three parts has been written and is now advertised as a special course. The second course—called the advanced machine design course—is intended for mechanical engineers, draftsmen, and designers, and is one that may be read with profit even by graduates of our best engineering schools. The preparation of such courses as these is sufficient evidence of the willingness of this school to give its students instruction of real educational value. However, the school has been compelled to respond to the demand for short courses with educational features cut to a minimum, and it seems likely that the laudable intention of the managers to make their school a force in engineering education is not likely to be realized.

In answer, then, to the question as to the ultimate position of the existing correspondence schools, it may be stated with confidence that these schools will probably retrograde rather than advance, and will finally fill the place of the trade school. Their graduates will be skilled workmen, not engineers. Even in this capacity, these schools will do a great deal of good, and should receive every encouragement.

Assuming that there will be no further development of the correspondence system of instruction by the existing correspondence schools, it is pertinent to inquire if the system has possibilities in other directions. It has been suggested that the state could inaugurate correspondence schools and place them under the supervision of the state university. Is there a class of would-be students to which such schools would appeal, and would the results that might be obtained justify the establishment of schools of this character? But before we consider these questions, let us examine for a moment the correspondence system *per se.*

Those that have had little or no experience with this system of instruction are likely to magnify its defects and to minimize its advantages. They dwell upon the advantages of the inspiration gained by personal contact with instructors and classmates, and upon the difficulties that beset the solitary correspondence student, who must wait weary days for answers to his questions. The correspondence system certainly has its disadvantages, the greatest of which is that the student has no stimulus but his own zeal and ambition to keep him steadfastly to his work. Unless he is blessed with a rather more than average share of perseverance, he is likely to drop his study after the novelty wears off. To offset this serious disadvantage, the correspondence system has one decided advantage that has been generally overlooked. The time required to cover a given subject by correspondence teaching is necessarily much longer than the time required to cover the same ground in the college classroom. Now in many subjects, as for example, calculus and mechanics, the time element is all important. To use a common expression such subjects require a certain minimum time to "soak in." The student in the university is given the whole subject of analytical mechanics in twelve or fourteen weeks. It is no wonder that his fundamental conceptions are hazy, that he doesn't know the difference between velocity and acceleration. Now in subjects of this character, the longer time required by the correspondence method is a distinct advantage. The student has time to think, and is not hurried to a new part of the subject until he has mastered what precedes.

The subjects that can be successfuly taught by correspondence methods are those of a precise and definite nature, as engineering drawing, descriptive geometry, mathematics, mechanics and applied mechanics ; also the English studies usually required in engineering courses. Of course, the lack of laboratory apparatus precludes the teaching by correspondence of subjects that require laboratory experiments. I am convinced that the subjects just named can be taught just as effectively and thoroughly by the correspondence method as by any other method, provided the students are intelligent and earnest.

Returning now to the question of State correspondence schools, it would seem that there is a well-defined field for just such schools. There are many young men who have had a good training in the common schools, perhaps in the high schools. They cannot enter technical colleges for lack of preparation, and yet they wish an education somewhat more complete than they could obtain from any of the correspondence schools. Again there are many that are fully prepared to enter the technical colleges, but cannot do so for lack of money; and there are many more, at any rate in western schools, that are forced to end their college careers at the end of the Sophomore or Junior year for lack of funds. With State correspondence schools, would it not be entirely feasible to prepare these young men to enter the Sophomore or even the Junior year of the engineering college? Why should not a large share of the purely academic work be done by correspondence?

These State correspondence schools would in no way conflict with the present private correspondence schools, as they would attract a class of students, small in number compared with the thousands enrolling in the private schools, though large in number compared with the number in attendance at the engineering colleges.

Regarding the details of the management of State correspondence schools, I have little to say; the best methods must be determined by experience. In my opinion such schools should be under the direct supervision of the State university, and the instructional work should be done at the university rather than elsewhere. The methods of the present correspondence schools would necessarily be modified in some respects. Thus existing text-books supplemented by explanatory notes could be used; if judiciously selected, such text-books would doubtless be better for the purpose than instruction papers hurriedly written and printed at a heavy expense. The routine work of correcting students' work and replying to students' questions would not be excessive in any one school. This work, which in the existing correspondence schools is largely done by young ladies, might well be entrusted to regular advanced students of the university. It would be a source of revenue for the students who need to earn money.

Possibly also it would be desirable to offer courses at stated times and to require students to complete given subjects within specified periods. Examinations could thus be given simultaneously to all the students in a subject. No doubt other details of management will suggest themselves to the members of the society.

DISCUSSION.

PROFESSOR JOHNSON said he had talked with the author of the paper upon this subject. He found that he had some mature and enlightened ideas with regard to it. He was not sure but that he specially requested him to write this paper for presentation to the society. There had been a little talk about the idea of a State correspondence school at Wisconsin. Inasmuch as there was in the literary department a correspondence school bureau, the question of extending it to the engineering department had been under consideration. It had been decided, however, not to do it, and the correspondence school in letters and science had been abandoned. Not that there is not a demand for it, and that there would not come to be a greater demand, but rather because the University was not qualified to do the work. The speaker was entirely convinced that the only way to do this was to prepare thoroughly for it and do it like any other business, by doing it effectually and making it the sole business of some one or more persons. In other words a new school would be necessary, and all the peculiar texts and methods that go with it. A system of answering letters and correspondence is needed, and in his opinion the text-book should be different from any that are used for present instruction. The correspondence schools now in existence have found this necessary. State universities would have to prepare a set of texts, and the whole thing is so difficult a matter that it is discouraging, and he thought should never be undertaken unless it is done with great foresight and consideration, and at a considerable expense. The speaker thought the paper was right, that there is a great field for this instruction, and if done by the State there would not be that temptation to pander to the wants of those who wish to get through quickly and cheaply, and it would attract a much higher grade of students. He was sure from what he had seen already in Wisconsin that several hundreds of students could be secured for such a course. He said that they were too busy, and the State would have to make a special provision, and establish in the university a correspondence school bureau, properly officered and with the necessary money for texts, teachers, etc., that would have to be forthcoming, and that of course a definite policy for such provision would have to be continued from Legislature to Legislature. He considered it a pretty big thing, and while he believed it to be a good thing, yet in Wisconsin they were not yet prepared to go into it. He was not sure but that they will come to it some of these days. In fact, he did a little work in the Legislature last spring, and found that they are very anxious that these higher educational opportunities should be extended to the mechanics and workmen out over the State, who cannot now have the advantage of them. The agricultural department does many of these things. It has farmers' institutes all over the State, and is establishing schools in butter- and cheese-making. Now it is said, why can't something be done for the young mechanics of the State? Well, if something could be done, however little, in that direction, it would greatly facilitate the State appropriations for the college of engineering. But the way had not seemed to be clear to do anything, as yet.

THE PRACTICABILITY OF AN INTERCHANGE OF STUDENTS BETWEEN THE LABORATORIES OF DIFFERENT ENGINEERING SCHOOLS

BY WILLIAM F. M. GOSS,

Professor of Experimental Engineering, Purdue University.

The development of American schools of engineering constitutes a significant phase of the nation's history. In recent years, the process has advanced by rapid strides. Colleges have multiplied in numbers and the work of individual institutions has extended into new fields. One result of this process of development, is to be seen in many well-equipped laboratories which never fail to exert an inspiring influence. Students and professors alike would look to the future with misgiving if not assured that the years which are to come would carry these laboratories to still higher stages of development. Since, therefore, the need of laboratories is likely to increase, it is but reasonable to ask by what means the required facilities can be most economically supplied.

Equipment designed for work that is purely elementary must generally be duplicated, each locality where classes assemble having its own laboratory, but the arguments favoring such duplication lose force as the work to be done becomes more advanced. Thus, every engineering student should have some opportunity to study experimentally the flow of water in orifices of simple form, but only those who are to specialize in the subject require an equipment of different types of hydraulic machines of commercial size. It is, therefore, not unreasonable to suppose that under the condition which must soon exist, a single laboratory designed for advanced work, can be made to serve two or more institutions, students passing from their own laboratory to that of a neighboring school, for a few days or a few weeks at a time, as the necessities of the case may require. The practicability of such an arrangement constitutes the question raised by this paper.

As tending to increase the difficulties of putting such a plan into action, it is to be noted that American educational institutions have not reached their present state of efficiency without some display of a spirit of rivalry, while in some cases antagonism and even jealousy have marked the onward movement. Under such conditions it is evident that no plan for the interchange of students could be operative, but these accompaniments of an unsettled condition and of a somewhat crude conception of the high purpose underlying the educational work of a great nation, have in recent years been diminishing in force and are now in many parts of our country almost entirely absent. Men charged with the responsibilities of determining the policy, and of administering the affairs of such institutions have come to look upon the trust imposed as a sacred one, and, inspired by high motives, they seek new ways in which the individual institution may serve the common good. Such a spirit is altogether worthy the cause and promises well for the future.

If the time has come when one institution can safely entrust a portion of its interests to the care of a neighbor, the problem of interchanging students resolves itself into a simple question concerning the extent of the advantage which would result from such a course. This may be answered by considering every piece of equipment as representing money invested. The fullest return from any such investment is had when the equipment is kept fully occupied. Under conditions now prevailing in many institutions there are expensive and important installations of apparatus which are not in use all the time, the demands of resident students being insufficient to fully occupy them. Under such conditions, viewing the problem as a whole, it is not good business practice for a neighboring institution to duplicate such a plant. It should rather invest its money in apparatus of a kind not possessed by the first mentioned institution. By so doing the two institutions may enjoy the same degree of equality which they would have if both were similarly equipped, with the additional advantage that by interchanging students, both could have increased facilities. Or viewing the result from the other side, the field consisting of the two institutions combined would be able to offer the largest possible facilities for a given investment of money.

If such a plan can be made operative between two institutions, it could probably be extended to three or even more; and since, by modern means of travel, local boundaries are largely eliminated, the neighborly arrangement could easily be made effective between institutions in several different States, each having, as at present, its own equipment for the early work of students, and one or more groups of equipment not possessed by the others designed to serve in some special line of advanced research.

An objection that is likely to be raised to such a plan as has been outlined is that any institution yielding to its neighbor a clear field along certain lines of research, and limiting its own work to other lines, becomes content with a process which tends to suppress the individuality of instructors and which is therefore likely to be narrowing in its effect.

Such a result is not a necessary consequence. The fact is that the breadth of fields of engineering research which a few years ago were considered special and narrow, is now sufficient to challenge the ambition of the entire engineering staff of a modern institution, and a selection of subjects by institutions, would tend to individualize and to strengthen, rather than to narrow and weaken. The opportunities of individual professors also would not be diminished, but would be increased through the more constant use of the equipment in their charge.

Another objection which might have force is to be found in the danger that the allurements of the new institution would affect the visiting student's loyalty for his own, a result which, if realized, would unquestionably be harmful to the student's own best interests. If the proposition concerned young students the objection would have considerable force, but with those who are more mature, approaching their commencement season, allegiance to class and school would be very strong. It should be added, also, that the disadvantage under which the student would labor in having to make temporary changes of base, would be more than offset by the benefit he would derive from travel, from contact with other laboratories than his own, and from his wider acquaintance with men.

In conclusion it must be admitted that progress along the line proposed is beset with difficulties. Success implies a good understanding among the authorities of all institutions of a given group, and possibly some centralization of authority, though this need not be very formal, nor vested in so small a number of men as to be objectionable. It involves questions of responsibility, both as to the welfare of students and as to expenses on account of maintaining laboratories; also, such minor problems as the preparation required for different lines of work and as to the time entering into programs under which the interchange of students is to occur. But if it is true that the money which in coming years is to be spent in the upbuilding of school laboratories, can be made more productive by the adoption of such a plan as is proposed, the proposition should not be put aside because its complete development involves difficulties. Time will be required, but if the end is really desirable, the engineer will find means by which it may be reached.

THE MODERN MECHANICAL LABORATORY, ESPECIALLY AS IN PROCESS OF EVOLUTION IN AMERICA.*

BY ROBERT H. THURSTON,

Director of Sibley College, Cornell University.

[A paper prepared for presentation, jointly, to the International Congress on Applied Mechanics, Paris, 1900, and to the Society for Promotion of Engineering Education, New York, 1900.]

The organization in the United States of what have come to be known as the "Land Grant Colleges," founded upon the proceeds of sale of grants of land made by the general government in 1862, under what is known as the "Morrill bill," has given to the nation a large number of colleges and universities in which as, prescribed by law, the "leading object" must always be the instruction of students seeking such knowledge in the sciences and literatures fundamental to the scientific development of agriculture and the mechanic arts. These institutions have been fostered by the various States of the Union and their endowments supplemented, often, by large grants from the State itself, and they now constitute one of the most important and useful elements of the State systems of public education.

Among these land grant colleges, technical and scientific education and professional schools flourish as they could not possibly under any other conditions. Each such institution is a real university, in the sense that it embraces in its curriculum all the principal sciences, all the great literatures, and all the fundamental arts of the time, so far as it is practically possible to introduce these matters into the scientific curriculum. They include the ancient and the modern literatures and their languages, the history of ancient and modern peoples, the philosophies, the natural sciences, biology and the physical sciences in their latest developments, mathematics to the highest development appropriate to the university post-graduate departments and schools of law, of medicine, of architecture and of engineering. They are coming to be, for their time as comprehensive as was in its time the Alexandrian university of two thousand years ago and as has been no other institution of learning since the days of Hero, of Hipparchus, of Archimedes and of the Ptolemies. In these colleges are now developing, extensively and broadly, departments of investigation and research especially devoted to the prosecution of investigations called for by the needs of the engineering and constructive professions and their mechanical laboratories are coming to be extensive, important professionally and scientifically and very fruitful of discovery and systematic development of applied sciences.

---

* The manuscript of this paper was not received in time for presentation at the meeting.

There also exist in the United States a number of large and highly organized technical institutions, supported wholly or mainly by private endowments and by tuition fees paid by their students, in which a great work of a similar kind is in progress and there also exist, in connection with some departments of the general government, as with the Navy Department and with the Ordnance Bureau of the War Department, laboratories of various kinds in which work of the same general class is done, often on a very extensive scale. It is the purpose of this compilation to exhibit, as well as possible in so condensed a form, the work of representative institutions of these classes and to illustrate the character and extent of the mechanical laboratories of applied mechanics in the United States and to give some idea of the nature and value of their work.

In a discussion of the evolution of "Technical Education in the United States," at the Columbian International Exposition, at Chicago, in 1893, at the "World's Engineering Congress," the writer presented an extensive paper descriptive of the rise and progress of the modern technical forms of education in the United States and, among other matters, took up that of the laboratory of applied mechanics, the mechanical laboratory, as it is usually called. A portion of this discussion may be properly here quoted. Referring to the earlier origin of this feature of the modern scientific educational organization in the technical schools and departments of colleges, and the fact that, while original in Europe as a tool of research, it was first made a part of the regular equipment for instruction in the United States, it was there and then remarked :—

"The Mechanical Laboratory, the department of research of the modern American engineering school, has come to be so important and essential a division of the most successful schools and colleges of engineering that an article should be specially devoted to this subject. Although not recent in origin or absolutely modern in form and purpose, it is only within a comparatively short time that it has taken its proper place in the organization of these schools and commenced that work which has come, to-day, to be recognized, by engineers and educators alike, to be the most fruitful of result, the most beneficial to the student, and the most productive of both knowledge and discipline of all the methods of instruction and of study and practice forming parts of the contemporary scheme of engineering professional instruction."

According to the eminent Belgian authority on this subject Professor Dwelshauvers-Dery, the evolution of this form of organization for research began in Europe before it took shape in this country. In fact, the foundation of the Conservatoire des Arts et Metiers in Paris was probably the first step in this direction; and, especially under the direction of General Morin, and later, under Treoca, the prosecution of investigations having bearing upon and value in the work of the engineer became usual directions of research in that great school, and with most important and extensive result. As Laboulaye asserted: "*L'enseignement du Conservatoire des Arts et Métiers est le plus populaire en France. Constitué avec toutes les ressources de la science, initié à tous les dévelopments de l'industrie, dont il a pour mission de faire connaître le progrès, il est pour elle une source féconde de connaissances utilles, un guide sûr dans les applications.*" Of late years, however—since 1885—comparatively little work has been done in this celebrated old laboratory.

As early as 1825 the École des Mines of Stockholm employed a small testing machine in the investigation of the strength of the materials of engineering, under the direction of the distinguished Lagerjhielm; and Gerster, at Prague, at about the same time, perhaps even earlier, performed similar service for engineering science and, with his colleagues, introduced the steam engine indicator and Prony brake in the course of his work of instruction. In the year 1836 the École des Mines of Liege was using a collection, including a ten-ton testing machine, indicators, breaks, etc., in its course of instruction, and in 1843 the École des Ponts et Chaussées of Paris was supplied with testing machines for metals and for cement testing. The similar school at St. Petersburg was given an outfit of the same kind in 1853. By 1860 the use of apparatus of investigation in the solution of problems in engineering had become not at all uncommon; although a systematic scheme of organized research or of professional instruction such as the chemists and the physicists had long possessed had not even then taken shape. During and before the civil War in America, the United States Army and Navy officers had been accustomed to submit all the materials of ordnance and and machinery employed by them to systematic test under precisely worded specifications, and the legislation prescribing tests for steam-boilers and their material had become well crystallized; but it was not until about 1870 that engineering schools commenced the introduction of such apparatus and the construction of courses including their use both in instruction and in research.

King's College, London, the University of Edinburgh, and the Polytechnich at Zurich, introduced machinery of investigation in 1870. The Munich Laboratory, now under the direction of Professor Schroeter, was planned in 1871 by Professor Linde, whose enunciation of the principles governing its establishment and operation are well summarized in the following remark attributed to him by Dwelshauvers-Déry : "*Il est du plus haut intérêt pour notre école de faire de ce laboratoire un champ d'exercises pour les élèves. Le fait est constaté que le plupart des ingénieurs mécaniciens formés dans nos écoles n'arrivent jamais à faire un usage étendu de leur savoir théorique en perdent ainsi la connaissance. C'est que, dans ses formules mathématiques, la théorie ne tient pas compte de la variété infinie des conditions qui se présentent dans les cas spéciaux. . . . Sans doute l'abîme qui semble creusé entre la thêorie et la pratique n'est qu'apparent pour quiconque a pénétré la science à fond et sait manier avec indépendance les principes ; mais ceux-la seuls qui sont doués de talents éminents arrivent à ce résultat. C'est pourquoi l'école doit fournir aus élèves l'occasion de faire eux-memes des expériences, d'en discuter les résultants, et d'apprendre ainsi, en les comparant aux données de la théorie, à faire une juste application de celle-ci.*"

The learned professor formed his plans and submitted them to his government; but it was five years before he was permitted to offer to his students those facilities for systematic investigation which he had so early proposed.

College laboratories now promise to supply such information more extensively and more systematically and with greater accuracy than can probably any other means, with the possible exception of governmental laboratories like that at the Watertown Arsenal; which laboratories, however, rarely contain any large variety of apparatus or attempt more than a very limited range of work. In them the colleges find the most visibly fruitful work and the student his most productive line of study; while the profession and the world are, through them, securing larger and more useful contributions to the sum of useful knowledge than perhaps in any other method or field of work.

The plans of the writer for such a laboratory were inaugurated in 1871, when assuming charge of the engineering department of the Stevens Institute of Technology. The construction of a small testing machine was commenced in the following year, and the result of its first application in research, the discovery of "the exaltation of the normal elastic limits by strain," was announced to the American Society of Civil Engineers in 1873. Meantime, the collection of apparatus proceeded rapidly, considering the fact that a loan of a few hundred dollars from the Trustees of the school, the private means of the officer in charge, and such profits as could be obtained through commercial work in testing materials and machinery, were the only sources of the required capital. By 1875 the laboratory was so well provided with experimental apparatus as to be prepared to assume the responsibility of carrying on, under the direction of the writer, then the Secretary of the "United States Board appointed to test iron, steel and other metals," and chairman of several of its numerous committees, such investigations as were assigned him by the Board or asked for by other committees of that Board. The whole series of investigations of the copper-tin-zinc alloys and a number of other extensive lines of experimental work of investigation were carried on in the laboratory in 1875–78; and some of them, becoming recognized as valuable, the standing and reputation of the laboratory were so well established as to make it thereafter a permanent, continually growing institution for research in engineering.* Its work on the ternary alloys, just referred to, on the lubricants—the first extensive researches in this field—revealing the differences due to varying pressures, temperatures and speeds of rubbing, and its numerous investigations in all the various fields of modern engineering, have made it a recognized place in the list of such institutions.

For a number of years this laboratory was carried on independently, as a matter of finance, of the school with which it was connected, and the earnings derived from commercial work, sometimes reënforced by contributions of friends of the movement, paid the salaries of the assistant in charge and of the working force, and even, after a time, began largely to increase its own equipment and added something to that of the department of which it was an adjunct. During recent years, it has been distinctively a separate Department of Experimental Engineering, and an official connection with the institution has been established.

The Engineering Laboratories of the Massachusetts Institute of Technology date from about 1873, when

---

* Reports of the United States Board appointed to test iron, steel and other metals. 2 Vols., 8vo. Washington, Government Printing Office, 1875–78.

Professor Channing Whittaker commenced the work of collecting apparatus with the aid of Mr. George B. Dixwell, who placed in his hands a steam-engine fitted up with indicators, pyrometers and accessories required in the prosecution of an investigation of the internal thermal wastes of the engine and the effects of superheating in the reduction of such wastes. The results were published, and attracted great attention at the time. These laboratories now have an exceptionally extensive and costly outfit, including an "experimental steam-engine," a number of testing machines, some of great size and delicacy, and numerous minor apparatus. Its work in research is extensive and extending and all its students have the inestimable privilege of instruction in this work of investigation of the greater and lesser problems of engineering. The study of the operation of the triple-expansion engine, through the application of the Hirn calorimetric methods by Professor Peabody, and the earlier work of Professor Lanza on strength of heavy timbers, illustrate the magnitude and character of its operations. The engineering courses of the institute, like those of every other important school of engineering, are gradually coming to include, in these later years, more and more work of research, and better and better instruction in the methods of exact measurement and scientific investigation as applied to the problems of every-day engineering practice.

The Sibley College Laboratory, at Cornell University, is the latest and perhaps most extensive of those now rapidly taking form in the United States, and especially in the Land Grant and State colleges. It was organized by the writer, in 1885, as a department of instruction, as well as research, in that institution, and it has come to be already one of the largest and most productive of its various lines of work. It is supplied with a number of testing machines, ranging from 150, 100, 50, and 25 tons capacity down to the smaller torsion, transverse and impact machines, with several experimental engines of from 150 or 200 down to 5 or 6 H.P., perhaps as many air and gas engines, and a number of oil-testing machines ; together with a sufficient number of steam-engine indicators, gauges and miscellaneous apparatus required to meet the needs of senior and junior classes numbering from 125 to 150 men. Many graduate students and some undergraduates take up work in research, and the laboratory is thus rendered doubly productive. Professors engaged in their own investigations find the aid of such students very advantageous in matters of detail, and they often produce original work of real value. Besides the experience and training of the laboratory, the student secures often a still larger training by taking part in work conducted elsewhere, as in the testing of engines by the commercial branch of the establishment, and the investigation of efficiencies of the heating "plant" or of the water supply and water-power machinery of the college. Such work as this, and especially such as is illustrated by the great investigations of Bauschinger and of Schroeter, of Wohler and Spangenberg, now universally familiar to the profession, is adding constantly and enormously to the store of facts and data upon which successful practice in construction depends.

The compilation of descriptive papers sent to the expository must be taken, as a matter of course, as a collection of sample illustrations of the character of the institutions, the equipment and the methods and the product of such laboratories in the United States. There are very many such laboratories, often extensive, which are not there represented at all. Those which are described are very variously treated ; some being fully, but most of them being very briefly and inadequately described because of lack of time or opportunity on the part of the reporter or through a misunderstanding of the purpose of this body of contributions to the work of the International Congress. There is, however, quite enough to give a good idea of the manner in which the work is going on in this country and of the extent and fruitfulness of these institutions. It is hoped that the collection may prove useful in stimulating this development, so important to every nation, so productive of rapid and healthful advances in civilization, the world over, and in collaboration with the papers presented from other countries, in the promotion of improved methods of education and of research as well.

In the study of those papers it will be discovered that the introduction into the curriculum of the professional engineering school of a department of experimental engineering has come to be almost universal and that no such professional course is regarded as satisfactorily complete unless it includes systematic instruction extending over a very considerable period in this branch. The union of research with systematized instruction and the combination of practice in the experimental work of the expert professional will be seen to also constitute characteristic features of this department of educational work in the United States. The exhibits of the restricted number having places in the Exposition are illustrative of these points and an examination of their reports and of their compilations from the proceedings of technical associations, giving accounts of their work in research, particularly, may be referred to an illustration of the characteristics there referred to. In every important engineering school in the United States, the course of instruction includes a definite and usually liberal assignment of time to the work of experimental illustration of the properties of the materials of engineering, the testing of iron, steel, the alloys and their constituents, and often to investigations of the nature and properties of new materials and of the laws affecting the relations of composition, strength and resilience. Such experimental study is followed by investigations in a similar manner of the constructive values of various forms and proportions of the familiar or of rare metals and materials of various sorts, and this by extended experimental study of the various motors, heat, hydraulic and pneumatic and the related apparatus. In the usual case, the study of the steam- and gas-engines and the practice of the standard, conventional, methods of test-trial are given a very complete development and the students completing these courses of study and professional practice generally become competent to undertake any of the usual expert's investigations.

These courses of study and of professional practice and research are incorporated into the curriculum precisely as are the courses in mathematics, in applied mechanics or in the physical sciences—which are also taught, invariably, through laboratory methods and with extensive practice in manipulation. The reservation of the laboratories for the use of the professor-in-charge and his advanced pupils is unknown in the United States and the first purpose and the special use of the laboratories is invariably the practical instruction of the student, and commonly of the undergraduate student. It is no doubt in part for this reason that professional research has less development in the colleges of the country than it might otherwise have. On the other hand, the method adopted gives opportunity to many potential investigators, and discloses many otherwise undiscovered men of genius; so that it may perhaps be the fact, in the end, that the quantity of work in research and its quality may prove to be quite as great as it could be were the laboratories maintained, in the manner formally universal, for the use only of expert and advanced workers. However this may be, they certainly contribute most effectively to the production of a large body of professional men, skilled in the art of investigation and familiar with the underlying principles of science and the apparatus and methods of the investigator and his laboratory, through whom the profession and the country are enormously advantaged. Experience has already shown this system of professional college work to have immense advantages over the older method and to give to the profession a very capable and adaptable body of young aspirants to its larger rewards and positions of honor.

The change in later years in the character of the great body of the profession in the direction of scientific method and utilization of exact knowledge, in the conversion of the empiric into the man of science, has been extraordinarily marked.

The principle that the professional school of engineering, quite as much as that of medicine, should have its laboratories and its "clinics" was taken as fundamental by the writer then ignorant, when his laboratory was planned, in 1871, of the words of our colleague, Professor Linde, whose statement of the principles governing its establishment and operation are well summarized in the remark attributed to him by Dwelshauvers-Dery and already quoted.

He had become familiar with the work of General Morin; of M. Tresca, and of the then few authorities on experimental engineering in Great Britain and had studied with rare interest the reports of Wade and of Rodman, and of the small band of other investigators, mainly in the army and navy, who had turned their attention to the standing problems of engineering. He had endeavored, in a few instances, to solve, by direct instrumental research, problems which had come up in the course of his own then short professional experience; but it was evident to him, as to every member of the engineering profession, that an enormous work remained to be done to make the work of the profession scientific, accurate and systematic. Empiricism was the ruling feature of construction in those days. The extent to which this was then true may be judged by the fact that when he first undertook to prepare, in 1871, a treatise on the Materials of

Engineering, he anticipated completing it in two years. He was, however, so frequently and so long delayed by the necessity of filling an existing hiatus in experimental knowledge, and was so often compelled to resort to direct experiment with his own hands and apparatus, that it was over ten years before he was able to read proofs on his first volume and two years more before he saw the last page of the work in type.

Seeking to promote the growth of a then weak and uncertain enterprise, the writer published a statement in 1875, of which the following is the main portion of the argument:*

Introductory.—There are few men of any considerable practical experience in engineering who have not felt the great need of some well-established and reliable authority to which they could apply for special information, either purely scientific or more strictly professional, bearing upon unfamiliar details of their work.

Probably every man who has grown up in daily contact with any branch of mechanical industry has seen hundreds, and often thousands, of dollars expended in the effort to obtain such information, has seen the result accomplished, and yet this information, valuable as it was to many besides those who acquired it, remain unpublished. The world at large has been left as ignorant as before. Repetition of the work by others has followed, and a similar expenditure of money has produced the same limited result.

---

*On the necessity of a Mechanical Laboratory; Its Province and its Methods. By R. H. Thurston. A paper read before the American Railway Master Mechanics' Association. Journal of the Franklin Institute, 1875.

Where one thousand dollars properly expended in securing the desired knowledge would suffice, were the results properly communicated to the profession, ten thousand or twenty thousand dollars may be expended by many independent experimenters, each ignorant of the other's work; and, after all, the hundreds of others who might have been benefited receive no assistance.

In many other cases experiments have been carried on, and large sums of money expended upon them, without the slightest really new and valuable information being gained, either because the experimenters were unaccustomed to such work and had but a vague knowledge of the real object to be attained and still less knowledge of the proper method of obtaining it, or because of their unfamiliarity with the best methods of investigation, or in consequence of their ignorance of what had been already discovered and published by others. It often happens, also, that a long course of experiments or a most tedious, elaborate, and expensive investigation is comparatively barren of results in consequence of some apparently slight neglect which would not have occurred had the investigator been accustomed to such accurate work as is required. Again, it has very frequently happened that engineers have remained for many years in ignorance of the real nature of some familiar phenomenon, or of some important principle, simply because, in order to enable the subject to be intelligently studied in all its relations its complete investigation required a comparison of experiments made in the chemical or the physical laboratory, with the work of the mechanic.

The mechanical properties of materials; the effect of temperature upon the metals; the incrustation or corrosion of steam boilers; the value of lubricants; the heating power of fuels; all these, and many other, subjects require for their full investigation the highest talent of the chemist, and of the physicist, as well as of the engineer.

The serious necessity of the establishment of some great institution which should be solely devoted to the work of investigation of such scientific and professional problems as are daily being presented to the engineer and the mechanic, in the progress of regular work, was forcibly impressed upon the mind of the writer when—then but a boy amusing himself in workshop and drawing-room—he many years ago, found himself unable to obtain accurate information upon even the most important subjects involved in the design of the steam-engine, or in the proportions of its details, and especially information relative to those circumstances which determine the quality of the materials used. The size of a piston-rod, the thickness of a cylinder-head, the proportions of a crank-pin, were usually determined, in nearly every shop, not by rules based upon careful investigation of the strength of the material, but by "rule of thumb." The economical value of high steam and of expansion, the influences of piston-speed, the laws governing the deposition of the salts held in solution in spring water or in salt water; the effect of surface condensation on the efficiency of the engine and upon the durability of the boiler, were all subjects in regard to which engineers held widely discordant opinions. The real effect of heat and cold upon materials was uncertain, and the laws governing the resistance of metals to blows, it was asserted, were involved in mystery. When, in later years, he was intrusted with sometimes important work, more light was the reward of painstaking investigation, but it came slowly and was most unsatisfactory from its meagreness. Experience in the management as well as design of engines and machinery at sea and on shore, revealed still more fully a great want of information in the most important branches of engineering work. We are getting on more rapidly to-day, but still too slowly.

Abroad, some valuable work had been done—far more than in the United States, although something had been done here. Our knowledge of the strength of materials rested upon the researches of General Morin, of Tredgold, Hodgkinson, Fairbairn, and Barlow, of Chevandier, and Wertheim, and of Vicat. Kirkaldy, Styffe, and Bauschinger have made most valuable contributions. In this country, a committee of the Franklin Institute, and Captain Rodman and Major Wade of the Army, Chief Engineer W. H. Shock, of the Naval Engineer Corps, and a few others, have done good work, while Commander Beardslee, United States Navy, has, later, added important facts to those previously acquired. The experiments of Clark in England, of Bauschinger on the continent, and of Forney in the United States, have thrown some light on the methods of distribution of steam in locomotives. The labors of Tresca, of Morin, and of Coulomb on the laws and facts of friction were the basis of our knowledge of that subject. Our own

Professor Johnson gave us an immense amount of information relative to the values and characteristics of American coals; and Baron Von Weber had given us important knowledge relating to the permanent way, from experiments on European railroads. Thus we find that some valuable work has been done in every line of research which has become the standard that guides us in practical applications.

In nearly every case we shall find, on investigation, that the standard which conservatism insists upon our accepting as a guide in our work has been some time in existence, and that it is based upon experiments with materials which were quite different from those now in our markets, and that it was made when methods, now perhaps obsolete, were considered satisfactory. In every field of labor we strike on more or less unexplored paths, and find ourselves daily at a loss to determine the best method of doing our work. The best work yet done in the most important branches of research has usually been of such a broad character, and has demanded the expenditure of so much time and money that it has of necessity been done by governments or by wealthy corporate bodies.

Abroad, in the French "Conservatoire des Arts et Métiers"; and, for example, the laboratories of great technical schools of Europe, are found men competent to do good work, and who are assisted by the pecuniary aid of their governments. It thus happens that we owe very much to them. In this country the same system which gives us political freedom operates against the successful prosecution of such work under the patronage of the government. In matters of pure science, as some work of the Smithsonian Institution, in that of the Coast Survey, and in the occasional astronomical or geological expeditions carried out at public cost, the difficulties are not so serious. But investigations which have a directly practical bearing in engineering are liable to fall into the hands of those who are not thoroughly well prepared for the work.

It seems very certain that a really successful and permanently useful institution, devoted to investigation, must be partially, if not entirely, operated by individuals legally responsible and well known as qualified for their work.

Methods of Investigations.—The method of operation in the prosecution of any investigation may be detailed as follows:

(*a*) The investigator must first know definitely what phenomenon it is proposed to investigate. A vague desire to know more of any given subject is by no means sufficient to justify entering upon a work which may be found to be indefinite in its extent and infinite in its ramifications. As a rule, the more completely the work may be narrowed down the better. It must necessarily be ultimately resolved into one or more questions which may be stated with precision before any probably intelligent and remunerative work can be commenced.

For example: To determine the effect of cold upon rails and machinery, which has been so often attempted and which still remains to a considerable extent an unsolved problem, we may find ourselves compelled to resolve this question into several as, for instance:—

1. What is the effect of change of temperature upon the strength of pure iron?

2. What upon iron containing carbon chemically combined, *i. e.*, steel?

3. What upon iron containing carbon mechanically combined?

4. What upon iron containing sulphur chemically combined?

5. What upon iron containing phosphorus?

6. What upon iron containing silicon?

7. What upon iron containing cinder?

8. What upon steel containing sulphur?

9. What upon steel containing phosphorus?

10. What upon steel containing silicon?

11. What upon metal containing mixtures of these substances in the various proportions frequently met with?

12. What is the effect of change of temperature upon the ductility of all these metals?

And when we speak of the effect of low temperature we must not forget that it may have, and in fact does have, an effect in at least two ways: It will effect the resisting power of a material, especially under shock, not only by the change of molecular force which is due to the change of the relative distances of the molecules, but also by the simple fact of change of density itself.

(*b*) Having determined all of these several simple effects, it remains to collect them and to so group the results that the great law underlying their action may be detected; and then the often exceedingly difficult task arises of expressing the law mathematically or in some other way which may make the work practically useful. It is evident that this problem can only be solved by a combination of the intelligent efforts of the chemist and the physicist as well as of the engineer.

Thus, our simplest questions may, upon examination, be found to comprehend complex and often difficult problems, and may require for their solution the highest talent of not merely one man, but a number of specialists, all of whose labors must conspire to secure a satisfactory solution.

(*c*) After deciding precisely what is to be learned, the next step is usually to ascertain how much has already been done of the work thus determined and limited. This requires a careful examination of the records of previous professional work, often extending far back into earlier times; and it frequently happens that a vast amount may be gleaned, and the work immensely shortened, by studying the results already made public by native and foreign investigators. Much of the finest and most practically valuable work of their kinds which has been yet accomplished will be found described in French and German engineering works and periodicals. The long standard works of Morin and of others already mentioned are illustrations.

(*d*) Next after the labor of examining and collating earlier researches, comes the planning of the new investigation. This is as necessary a preliminary as is the designing of an engine before work is commenced upon it in the shop. A thoroughly considered and well matured plan of operation will usually prevent any serious errors involving expenditure of money, or, equally important, the loss of valuable time.

The formation of a plan of operations requires a very definite knowledge of the character of the problem, an accurate understanding of the relative importance and probable bearing of the anticipated results, and a knowledge of the facilities available for the investigation. It presupposes a knowledge of the adaptation, range, accuracy and reliability of the apparatus to be used; and not less important than all this is a knowledge of the extent to which assistance must be asked of, and how far aid may be expected from, special researches of a more purely scientific nature. Skill in experimentation thus guided will produce the best results attainable with the means at hand.

(*e*) The next requirement is a proper collation and registration of results, a work in which there is opportunity to make useful a considerable degree of ingenuity and talent.

(*f*) To make correct deductions from the records is the final task, and this is exceedingly important. A lack of knowledge of the subject or of collateral facts may destroy the value of the whole work.

This work being properly done, and the account of the research being properly written out, a contribution to knowledge will usually be found to have been thus secured which has a value to the public, and sometimes to individuals, far exceeding that of the time and money expended in securing it. Men of science have often devoted the best years of a lifetime to the investigation of a single train of phenomena, seemingly insignificant in comparison with the great facts surrounding them; yet neither they nor the world think this a wasteful expenditure of time. The value of acquired knowledge is never to be measured by the value of immediately apparent results or of evident applications; yet, in the course of the practice of the engineer and the mechanic, it rarely happens that such experimental work as he is compelled to take in hand does not bring an immediate and ample remuneration; while the ultimate benefit accruing is often immensely great in proportion to what is paid for it.

We usually find that we help ourselves by such work to a most satisfactory extent, and, at the same time, are enabled to give our neighbors of our light without sacrifice, and to experience the gratification of benefiting the profession and the public.

Locating a Mechanical Laboratory.—The location of such an establishment as would be well adapted to general work of the kind here contemplated, and to the prosecution of special investigation of a directly or indirectly practical character should be carefully selected.

The necessity of frequently calling for advice and assistance of both practical and scientific men, and the desirability of securing accessibility, will prevent its satisfactory operation if it is not located so as to be within reach of a large number most interested in its establishment and maintenance.

The necessity which will frequently arise of making accessory investigations of a scientific character, in various branches of natural science, will dictate its establishment, probably, in connection with some well-established extensive institution of learning, provided with well-stocked laboratories, conducted by men capable of appreciating the importance of the work and of properly pursuing such investigations, and who will take an interest in the subject.

The institution should have a character which is readily defined ; its magnitude is not so easily determined. It may be of very limited extent, and may yet do a vast amount of good ; or it may become a great establishment, employing a large corps of able men, making use of extensive collections of valuable apparatus and machinery, and making profitable use of larger capital than the French "Conservatoire des Arts et Metiers," which has an annual income of nearly seven hundred thousand francs, five hundred thousand of which come from the State. In a large and growing country like ours, peopled by the most active and enterprising of every race, the future of such an institution, if properly managed, would be whatever its managers and those whom they aid might choose to make it.

Its stock of apparatus would be determined, in character and extent, by the nature of the work most imperatively needed. It would probably comprise a set of machines for testing the strength, and other no less important qualities, of the materials of construction, dynamometric apparatus, instruments for testing lubricants, steam-engine indicators, calorimeters, pyrometers and thermometers, and apparatus for determining the heating power of fuels. A standard mercurial gauge with the usual accessories for comparing other gauges, standard weights and measures, instruments for determining specific gravity, and other well known forms of experimental apparatus would be needed.

Special apparatus and instruments adapted to new methods of investigation and new fields of research would rapidly accumulate, as they might be constructed for special purposes or contributed from outside sources, and would ultimately form a collection of very great value. A collection of machine-tools would be needed for the purpose of preparing materials and of making or preparing apparatus.

The Personnel.—The personnel of this establishment would probably consist of a director who should be, if possible, familiar at once with the theory and practice of the profession of engineering, and who should also have as large a knowledge as possible of science, and particularly in its bearing upon his work. He should have able assistants of similar qualifications, and should be able to appeal to men of science and to practical men, alike, for advice, with confidence that it would be given and that it could be profited by. Good mechanics to take charge of tools, to aid in preparing apparatus, and to assist in manipulation, and some unskilled labor, would complete the list.

Such an institution as has been here briefly described, doing the work which is most immediately required by the various branches of manufacturing industry and of engineering, would be of incalculable benefit to mankind. As elsewhere remarked by the writer, such an enterprise "would give to this country an institution such as has never yet been organized, and one whose value would prove beyond estimation. The accumulation of facts, the valuable application of science, and the directly practical bearing of the work which may be done, would in a comparatively short time be productive of richer results than have been attained in constructive science during many previous years. It would do most effectively that work which has been hitherto too much neglected, the application of scientific knowledge to familiar work and to matters of business. It would do much to close up the space which, often, so widely separates the man of business from the man of science, and would lead to a far more perfect system of mutual aid than has yet existed."

It would, by aiding the progress of improvement in our methods of work, and by the application of scientific knowledge in practical life, and in the development of our material resources, lend a new impetus to the industrial enterprises of our people, and assist, to an extent which can probably hardly be conceived, in the promotion of our national prosperity.

A decade of such work as could and should be done, when such facilities are rendered available, may be expected to be more fruitful of practically useful results than a quarter of a century of unsystematic, desultory, and unorganized efforts, such as has hitherto been our only method of acquiring information.

The preceding statement, published in 1875, and distributed widely through the periodical literature of the time, and in pamphlet form, was influential, undoubtedly, to a considerable extent, in attracting the attention of leading members of the profession, of broad-minded educators, and of a number of statesman-like legislators to the subject which was already beginning to be recognized, throughout the world, by such men, as one of the great elements both of technical education in its higher levels and of industrial advancement by logical and scientific, and thoroughly effective and productive methods. European governments and countries had long before commenced the organization of governmental laboratories, in connection with their great technical schools and engineering colleges, and the beginning here made in the incorporation of systematic research in practical fields of applied science into the *curriculum* of the school attracted much attention.*

---

* An Engineering Experiment Station. Sibley Journal, 1897.

OPERATING WORK AS A FEATURE OF ELECTRICAL LABORATORY TRAINING.*

BY WILLIAM S. ALDRICH,

Professor of Electrical Engineering, University of Illinois.

In the representative institutions the engineering courses are now so organized that the junior student enters the engineering laboratory fresh from the work in the physical laboratory, covering a period of one or two years. Advanced work along similar lines is carried on in many cases for a year or two after the student has seriously entered upon his professional studies. The earlier training has necessarily been made up largely of work of a qualitative character by way of illustration and demonstration, familiarizing the student with the fundamental phenomena of physics and the simple application of principles and laws. The later training has been more quantitative in character, acquainting the student with some of the exact methods of modern experimental work in the establishment of laws and the accurate determination of constants in physical science.

Accompanying such work, but surely in consequence of it, the student should early assume toward all phenomena and problems in the realm of physics that attitude so characteristic of the scientific mind, while in many instances a real taste for scientific investigations will have been developed in the physical laboratory. Granting the thoroughness of such training by which the student has been drilled in physical measurements and exact methods of experimentation there would seem to be less necessity for attempting similar training in the engineering laboratory. More time is therefore available for developing the latter along engineering lines.

---

* The MS. of this paper was not received in time for presentation at the meeting on account of delay in transmission.

The work of physical and of engineering laboratories very naturally overlap each other. No hard and fast line can be drawn between them. Even if it were possible to define clearly the limits of the field which each occupies it becomes daily more impossible to do so, with each advance in physical science and growing industrial applications of the same.

In the engineering laboratory the primary objects of study are the sources of energy and the so-called working fluids, productive processes, the materials of construction, engineering appliances, mechanisms and machinery. Here are investigated the properties of water, steam, gas and electricity with special reference to their industrial applications; the chemical, physical, mechanical, electrical, magnetic properties of materials, as the case may require; the functional operation and relations of mechanisms, machinery and prime movers and their performance in detail or in the aggregate.

The bearing of these considerations upon electrical laboratory training is obvious. Preceding experimental work with new electrical appliances or processes there should be carefully arranged work along the following lines: study, inspection, illustration and demonstration, and operation.

By thorough study of actual and typical appliances the necessary preliminary electrical and mechanical data are secured. By inspection the student is assured of the electrical, magnetic, and mechanical conditions of the apparatus essential for successful operation of the same. By way of illustration and demonstration he is familiarized with the phenomena and principles underlying the functional working of apparatus and the handling of instruments and circuits. By actual operation of the appliances he acquires that familiarity, facility, confidence, and resourcefulness so essential for the satisfactory handling of electrical circuits.

Training in handling electrical machinery is quite as essential as training in electrical measurements. The one should be done and the other not left undone. If with all of his familiarity with galvanometer work the young electrical engineer is left to the mercy of the wireman or of the operating engineer, then his laboratory training has been incomplete. A knowledge of the behavior of electrical machinery and confidence in handling electrical circuits are becoming more necessary with each widening use of electricity. Nothing will ever take the place of that knowledge of electricity which can only be acquired by the handling of electrical appliances and circuits. Given a reasonable amount of time such information is now readily obtainable at first hand in almost any electrical engineering laboratory in the country. Expensive special equipment is not necessary, but thorough and varied equipment is essential, and should be kept right up to date. A thorough working knowledge of electricity will at once commend the young engineer to the older members of the profession and in a way which will insure respect and consideration. In electrical engineering a man must not only know his subject in common with similar requirements of other professions, but he must particularly know the phenomena and the behavior of electricity. These remarks will be seen to be all the more pertinent upon considering the utilization of alternating currents and the operation of alternating current machinery, constituting to-day a most interesting and important field with which the student cannot become too familiar.

With the object of presenting something definite along this line there are appended schedules for the study, inspection, illustration and demonstration, and operation of electrical appliances; also, instructions for students in a working organization of classes into sections of six, each with blank form to be used by the section leader for any given day's work. Such an organization has a double advantage: it not only greatly facilitates the laboratory instruction, increasing its efficiency, but it gives each student in turn a certain amount of training in executive work. This latter is of a character that he may be called upon to assume at any time in charge of the testing department of an engineer's practice or of a manufacturing establishment, as well as in charge of any electrical installation or power plant. In the one case he will have a corps of technical graduates under him; in the other, a gang of operatives; and, in both cases he will have use for all of the knowledge of human nature he can muster together from undergraduate and postgraduate experiences. The time has gone by when all that the young electrical engineer expected to do was to press the button, while some one else did the rest. He must have some knowledge of handling men as well as electricity, especially in such a professional field as electrical engineering where one touch of nature makes all akin.

It is the result of experience that students who have been given a course of laboratory training involving study, inspection, demonstration and operation of electrical appliances have a better understanding of testing the same than if they had been put at once into the latter without any attention to the former. Also, that an organization of the class into sections, as outlined, develops leadership and executive ability and admirably prepares for the culminating work of such training, the twenty-four-hour-test of an electric power plant.

Department of Electrical Engineering.
University of Illinois.

I.—Study of Electrical Appliances. E. E. Schedule 0.1.

1. Examine thoroughly the assigned apparatus, appliance, or device.
2. Take apart, disconnect, and note details of construction.
3. Reassemble, set up, or connect, as originally assigned.
4. Sketch circuits, arrangements, and details, as follows:
    - (*a*) All electrical circuits.
    - (*b*) All magnetic circuits.
    - (*c*) General arrangements and such details as may be specified, showing plan, elevation, and section, if possible.
    - (*d*) Dimensioned sketches of structural parts, details as specified.
5. Measurements and dimensions of structural parts, as specified.

6. Report on the work done, giving a written account of the same, describing the object assigned for study, and explain its uses and the functions of its several parts.

II.—Inspection of Electrical Appliances.

E. E. Schedule 0.2.

1. Inspect thoroughly the assigned apparatus, appliance, device or other object set apart for such work.
2. Take apart and disconnect ; re-assemble, set up, or connect as may be necessary for thorough inspection.
3. Mechanical inspection : inspect the following features and details in all instances to which they apply.
    - (*a*) General appearance and cleanliness.
    - (*b*) Freedom of movement of mechanical, electrical, or magnetic mechanisms.
    - (*c*) Character of adjustments necessary to operation.
    - (*d*) Armatures : clearance, balance,—static and dynamic.
    - (*e*) Lining up for operation,—shafts, belting, etc.
    - (*f*) Lubrication.
    - (*g*) Final adjustments for operation : belt, speed, etc.
4. Electrical inspection : chiefly by use of magneto and voltmeter.
    - (*a*) Electrical inspection by magneto.
        - (*a*–1) Field frame, simple grounds.
        - (*a*–2) Field coils, each, individually, for open circuits, crosses, and grounds.
        - (*a*–3) Armatures : closed coil types, for open circuits and grounds ; open coil types, for an open coil, crosses, and grounds.
    - (*b*) Electrical inspection by voltmeter.
        - (*b*–1) By millivoltmeter for short circuits in each field coil and in armature windings.
        - (*b*–2) Locate bad contacts by millivoltmeter.

(*b*–3) Inspect for quality of insulation, if injured or faulty; for approximate insulation resistance; for leakage of current under normal conditions.

5. Inspect for short circuit in armature windings of direct or of alternating current machines.
6. Magnetic inspection: chiefly by compass needle.
   (*a*) For magnetization of field or mechanism.
   (*b*) For direction of magnetic polarity.
   (*c*) For magnetic balance, as in armatures: radial, longitudinal.
7. Note: for primary cells and storage batteries, inspect for
   (*a*) Condition of electrolyte, quantity, quality.
   (*b*) Condition of electrodes.
   (*c*) State and condition of charge of storage batteries.
8. Note: for dynamo-electric machinery, in particular, as follows:
   General:
   (*a*) Sparking at brushes.
   (*b*) Heating of armatures, field coils, bearings.
   (*c*) Noise.
   (*d*) Speed high or low.
   Motor:
   (*e*) Stops or fails to start, direction of rotation.
   Dynamo:
   (*f*) Dynamo fails to generate.

See A.I.E.E., Vol. XI., 1894. Parkhurst's Schedule "Diseases of Dynamos."

III.—Illustration and Demonstration. E. E.
Schedule 0.3.

1. Illustration of electrical and magnetic phenomena, singly and in combination.
   (*a*) Electro-chemical fields: generation, electrolysis, storage, etc.
   (*b*) Electro-thermal work: heating effects of currents,

calorimetry, lighting by incandescence, the electric arc, electric furnaces, etc.

- (*c*) Electro-dynamic effects: induction, motion, fields of force, etc.
- (*d*) Magnetic phenomena: fields of force, distribution, strength of fields, useful and waste flux, leakage, magnetization, etc.
- (*e*) Electro-magnetic phenomena: induction experiments, establishment of E. M. F. magnetizing force and ampere turns, elements of dynamos and of motors of various types and windings, etc.

2. Effects of combinations and limits within which phenomena are available for practical utilization.
3. Use of instruments: (*a*) mechanical; (*b*) electrical; (*c*) magnetic.
4. Precautions to be observed:
    - (*a*) In handling instruments. See Instruction Sheets.
    - (*b*) In taking observations.
    - (*c*) In making measurements and in the use of constants.
    - (*d*) In connecting up the work for measurements.
    - (*e*) In operating apparatus, machines, etc.
5. Possible sources of errors:
    - (*a*) In handling the instruments.
    - (*b*) In connections, etc.
    - (*c*) In machines or apparatus used.
    - (*d*) In nature of the motive-power, force, or current used.
    - (*e*) In constants used, whether given or derived.
6. The reduction of observations: use of Least Squares, graphical and analytical methods of stating results, deriving formulæ, laws, constants, etc.
7. Illustrations of fundamental principles, corroboration of laws, etc.
8. Illustrate operation of apparatus, machines, etc. See Operation Schedule.
9. Characteristics of performance, constants, etc.

10. Testing methods, illustrated by examples of typical tests.
11. How results are discussed and conclusions drawn.

IV.—Operation of Electrical Appliances.

E. E. Schedule 0.4.

1. Thoroughly clean everything before starting any work.
2. Examine for any loose parts, fittings, connections, screws, etc.
3. Fill oil cups and insure good lubrication.
4. Adjust, line up, tighten belts to ordinary tensions, and make any other preliminary adjustments required by the work.
5. Have all switches open, cut-outs fused, obstructions cleared, and every freedom of movement necessary for successful operation.
6. Voltmeter, ammeter, pilot lights, etc., to be used, to watch building up (as of machine) or other line of preliminary operation.
7. Start up machine or apparatus, as may be necessary.

Note.—For dynamos, motors, transformers, etc., see the special Operation Schedules.

8. Examine functional working of machine or apparatus, for definite results.
9. Examine performance of appliance as to regulation, control, etc.
10. Experimentally determine best operating conditions, for highest efficiency, economy, or such other feature as may be required in operation.
11. Coupling, mechanically or electrically; working in parallel, synchronizing, etc.
12. Stopping, disconnecting, and cleaning up.

Instructions for Sections in Electical Engineering Laboratory.

Memoranda:

(1) The Class will be divided into sections of about six (6) members, each, arranged alphabetically.

(2) Section Leaders will follow each other in the same order of rotation.

(3) All other members of the section follow each other in same alphabetical order, for assigned duties, as follows:

One Recorder.
Two Switchboard Attendants.
Two Dynamo Tenders.

General Instructions for all members of sections:

(1) Obtain copies of all Schedules and Forms, note details of the same and of the assignments, as posted for given day.

(2) Become familiar with all features of the schedule.

(3) Study all references to Laboratory Manuals, etc.

(4) Each member is to hand in a report on all of the work performed by his section, according to assigned Form.

Instructions for Section Leaders:

(1) Become familiar with the apparatus to be used.

(2) Prepare wiring diagrams of all connections required.

(3) Preliminary run: ascertain best operating conditions.

(4) Determine upon and assign observation points.

(5) Give signal when observations are to be taken.

(6) Leave everything cleaned up, ready for next section.

(7) Hand in Section Leader's Report, before leaving.

Instructions for Recorders: See Instructions for use of Electrical Engineering Laboratory Note Books.

(1) Prepare schedule of headings for tabulation of readings.

(2) Make wiring diagrams of connections, as used.

(3) Keep the log: record readings and note conditions.

(4) Dictate the log to the other members of the section at the close.

Instructions for Switchboard Attendants: See Instructions for the use of Instruments.

(1) Obtain all instruments of proper capacity.

(2) Connect instruments to external circuits, ready for use.
(3) Take all readings from these instruments.
(4) Operate controlling and power-absorbing devices.
(7) Stand by for any emergencies.
(6) Disconnect, clean, and return instruments.

Instructions for Dynamo Tenders : See the Special Operation Schedules.

(1) Attend to all work about the appliances used.
(2) Get everything ready for operation.
(3) Connect all wiring to and from the apparatus.
(4) Obtain measuring instruments for use at the apparatus.
(5) Take all readings of instruments at the apparatus.
(6) Secure satisfactory operation during experiment.
(7) Clean up and leave in satisfactory working order.

SECTION LEADER'S REPORT: TO BE HANDED IN, PROPERLY FILLED OUT, IMMEDIATELY AFTER COMPLETING THE WORK OF THE DAY.

No. of Experiment........... Date......................

Apparatus used ....

Condition of apparatus when work was completed...........

....

Instruments used (give name and Laboratory Catalogue No.)

....

....

Condition of instrument when put away.......................

....

Outline of work accomplished ....

....

....

Combinations, made as per schedule ....

....

Special combinations or work...

....

Difficulties encountered.. ....

....

Precautions observed ....

....

Possible sources of errors ....

....

E. E. Course No........... Signed...................................

Class........... Section ....

HERBERT GUERNSEY GEER,

Died March 7, 1900.*

Herbert Guernsey Geer was born in Ogdensburg, N. Y., March 13, 1869. In 1883, after the death of his father, the family moved to Potsdam. Four years later Mr. Geer graduated from the State Normal School at that place and entered Cornell University. He received his degree of mechanical engineer (in electrical engineering) in 1893, having meanwhile been out of the University for two years as a telegraph operator on the Union Pacific and Southern Pacific Railroads.

He made a fine record as a student and immediately upon graduation was appointed an instructor in mechanical engineering in Johns Hopkins University. Two years later he was promoted to the rank of Associate. He conducted courses in steam engineering and machine design, and according to the testimony of his colleagues enjoyed marked success as a teacher and deserved popularity with the students.

On his retirement from the University in 1899, at the reorganization of the department, he opened an office in Baltimore as a consulting engineer. He began his career in this field in 1897 when the formation of a company for the construction of a novel type of steam boiler gave him an opportunity to demonstrate his ability as a designer.

He designed and installed several light, heat and power plants, the largest one being that of the Maryland State penitentiary. His construction of a 180 K. W. lighting plant with storage battery adjunct was one of the first examples of that system which was practically satisfactory. He did considerable work in testing engines, boilers, etc., and received a commission from the national government as heating and ventilating engineer for the postoffice building at Norfolk, Va.

He was a member of the American Society of Mechanical Engineers, the Franklin Institute, the Engineers Club of Philadelphia, as well as of the Society for the Promotion of Engineering Education.

His sterling manly qualities, marked intellectual ability, high ideals, enthusiasm and devotion to his work, all gave fine promise for the future, and make his loss a great one to the profession as well as to his family and friends.

---

* Memoir prepared by the Secretary, from information furnished by the family and by Prof. R. H. Thurston.

Library

INDEX.

PAGE.

Address by the President, Ira O. Baker . . . 11
Agricultural Colleges, State . . . 37
Alderson, V. C., Discussions . . . 206, 292
Aldrich, W. S., Operating Work as a Feature of Electrical Laboratory Training . . . 359
Allen, C. F. Discussions . . . 81, 87, 99, 150, 174, 208, 234, 293
Amendment to the Constitution . . . 6
Apprenticeship, Old System of . . . 107
Architectural Education, Development and Present Status of . . . 256
  “ Schools of England . . . 267
  “ Schools of France . . . 280
  “ Schools of Germany . . . 260
  “ Schools in the United States . . . 258
Arrangement of a Course of Study in Civil Engineering . . . 223
Art Education . . . 34
Ayres, B., Discussions . . . 72, 151, 208, 290

Baker, I. O., Communication to the Society . . . 1
  “ Engineering Education in the United States at the End of the Century . . . 11
Bending, E. A., The Manual Training High School in General and in Engineering Education . . . 295
Brooks, J. P., Discussion . . . 156
  “ Personality in Teaching . . . 141
Business Methods in Teaching Engineering . . . 157

Caldwell, F. C., Discussions . . . 170, 255
Characteristic Features of the Teaching of a Course in Mathematics for Engineering Students . . . 308
Cilley, F. H., Discussion . . . 178
Civil Engineering, Arrangement of a Course of Study in . . . 223
College Entrance Examination Board, Joint . . . 137
Colleges, Higher Engineering . . . 38
  “ State Agricultural and Mechanical . . . 37
Commerce, Higher Colleges of . . . 56
Committee, Auditing, Appointment of . . . 3
  “ on Entrance Requirements for Engineering Colleges, Enlargement of . . . 136

Committee on Entrance Requirements, Informal Report of 136
" Organization of 138
" Industrial Education, Preliminary Report of 28
" Nominating, Appointment of 3
" Report of 5, 6
" on Statistics of Engineering Education, Appointment of . 5
Committees, List of v
Constitution xxvii
" Amendment to the 6
Contents, Table of iii
Correspondence Instruction, Possibilities of 315
" Schools 74, 117, 289
" Technical Schools 49
Council, Election of 6
" List of vi
Council, Rules Governing the xxviii
Councils, Members of Previous xxvi

Day Classes 278
Deceased Members xxiv
Development and Present Status of Architectural Education 256

Eddy, H. T., Report of Committee on Industrial Education 28
Education, American Industrial, What shall it be? 28
" Architectural 256
" Art 34
" Engineering, Manual Training High School 295
" " Projection Lantern in 247
" " Promotion of 191
" " in the United States at the End of the Century, 11
" " in the United States, Present Status and Tendencies of 181
" Secondary Technical 102
Election of Council 6
" " Members 3, 4
" " Officers 6
Electrical Course, Two-year 133
" Lines, Secondary Technical Education in 102
Electrical Laboratory Training 359
Engineering, Business Methods in Teaching 157
" Civil, Arrangement of a Course of Study in 223
" Colleges, Higher 38
" Education in the United States, Present Status and Tendencies of 181
Engineering Education, Manual Training High School in 295
" " Projection Lantern in 247

Engineering Education, Promotion of 191
" Schools, Interchange of Students between the Laboratories of . 326
" " Original Investigations by, a Duty 235
" Students, Course in Mathematics for 308
" Training for 132
Entrance Requirements for Engineering Colleges 136
Evening Schools, City and Endowed 51
" " Y. M. C. A. 52
" Technical Schools 113
" Trade Schools 113
Examination Board, Joint College Entrance 137

Fellowships in Architecture 287
Fletcher, Robert, Discussions 211, 293
" Presiding at the Annual Meeting 1
" The Present Status and Tendencies of Engineering Education in the United States 181
French, A., W., Discussions 153, 223

Geer, H. G., Memoir of 371
Geographical Distribution of Members xxiii
Goodenough, G. A., Possibilities of Correspondence Instruction 315
Goss, W. F. M., The Practicability of an Interchange of Students between the Laboratories of Different Engineering Schools 326
Gray, Thomas, Discussions. 151, 177, 244

Half-time Self-supporting Trade Schools. 53, 68
Halsey, F. A., Discussion 98
Haynes, A. E., What should be the Characteristic Features of the Teaching of a Course in Mathematics for Engineering Students 308
Hazen, J. V., Discussions 233
Higgins, M. P., Discussions 62, 88

Industrial Education, American, What shall it be 28
" Preliminary Report of Committee on 28
Industrial Works, Supplementary Schools for 47
Interchange of Students between the Laboratories of Different Engineering Schools 326
Investigations, Original, by Engineering Schools a Duty to the Public and to the Profession 235

Jackson, D. C., Discussions 70, 153, 179, 204, 221
Jacoby H. S., Discussions 171, 178, 233
" Memoir of H. G. Geer 371
" Minor Considerations Affecting the Arrangement of a Course of Study in Civil Engineering 223

Johnson, J. B., Discussions, 100, 155, 172, 231, 323
" Report of Committee on Industrial Education 28
Journals, Scientific, Technical and Trade 55
Kent, William, Discussions 86, 90
Kingsbury, Albert, Acting Secretary at the Annual Meeting

Laboratory, Modern Mechanical 331
Laboratory Training, Electrical 359
Landreth, O. H., Discussion 175
Lantern, Projection, in Engineering Education 247
Lanza, G., Discussions 89, 154, 204
Libraries, Public 55

McNair, F. W., Discussions 90, 139
Magruder, W. T., " 86, 178
Manufacturer, Relations of the Technical School and the 213
Manual Training and Art Education 34
" " High School 110
" " " in General and in Engineering Education, 295
" " School 31, 81, 85, 90, 94, 100
Marburg, Edgar, Report of Committee on Industrial Education 28
" " " of the Secretary 8
Marston, Anson, Original Investigations by Engineering Schools a Duty to the Public and to the Profession 235
Mathematics for Engineering Students 308
Mechanical Colleges, State 37
" Laboratory, Modern 331
" Lines, Secondary Technical Education in 102
Mees, C. L., Discussion 199
Meier, E. D., " 92
Members, Deceased xxiv
" Election of 3, 4
" Geographical Distribution of xxiii
Members, List of vii
" of Previous Councils xxvi
Memoir 371
Mendenhall, T. C., Discussion 59
Merriman, M., Discussions 139, 232
Minor Considerations Affecting the Arrangement of a Course of Study in Civil Engineering 223
Modern Mechanical Laboratory, especially as in Process of Evolution in America 331
Monotechnic or Trade Schools 39

Officers, Election of 6

Officers, List of v
" Past xxv
Original Investigation by Engineering Schools a Duty to the Public and to the Profession 235
Operating Work as a Feature of Electrical Laboratory Training 359

Past Officers xxv
Personality in Teaching 141
Possibilities of Correspondence Instruction 315
Practicability of an Interchange of Students between the Laboratories of Different Engineering Schools 326
Present Status and Tendencies of Engineering Education in the United States 181
President, Address by the 11
" Communication from the 1
Proceedings 1
Projection Lantern in Engineering Education 247
Promotion of Engineering Education 191
Proprietary Trade Schools 47
Prout, H. G., Discussion 59

Raymond, W. G., Discussions 211, 230, 234
" The Promotion of Engineering Education 191
Relations of the Technical School to the Manufacturer 213
Report of the Nominating Committee 5, 6
" Secretary. 8
" Treasurer 9
Rice, A. L., Business Methods in Teaching Engineering 157
" Discussion 173
Richards, C. R., The Projection Lantern in Engineering Education . . 247
Rothwell, R. P., Discussion 74
Rules Governing the Council xxviii

Secondary Technical Education in Mechanical and Electrical Lines . . 102
" School 119
Secretary, Report of the 8
Snow, W. B., Discussion 176
" The Relations of the Technical School and the Manufacturer 213
Sunday Technical Schools 52
Supplementary Schools for Industrial workers 47
Swain, G. F., Report of Committee on Industrial Education 28

Technical Course, Two-year 129, 130
" Education, Secondary 102
" School and the Manufacturer, Relations of the 213
" Schools, Evening 113

Technical Schools, Sunday 52
Thurston, R. H., Report of Committee on Industrial Education 28
" The Modern Mechanical Laboratory as in Process of Evolution in America 331
Trade Schools 39
Trade Schools, Day. 112
" " Evening 113
" " Half-time Self-supporting. 53, 68
" " Proprietary. 47
Teaching Engineering, Business Methods in. 157
" Personality in 141
Thomas, B. F., Discussion 152
Treasurer. Report of the. 9
Tyler, H. W., Discussions. 139, 206
" " Entrance Requirements for Engineering Colleges 136

Waldo, C. A., Report of the Treasurer 9
White, J. M., Discussion 85
" " The Development and Present Status of Architectural Education 256
Williston, A. L., Discussions 173, 174
" " Secondary Technical Education in Mechanical and Electrical Lines 102
Woodward, C. M., Report of Committee on Industrial Education . . . 28
Woodward, R. S., Discussions 71, 172, 173, 178, 201, 291
" " Vote of Thanks to 7